LONGEVITY OF *CORYNEBACTERIUM TRITICI* CAUSING TUNDU DISEASE OF WHEAT

By

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Corynebacterium tritici (Hutchinson) Burkholder, the cause of 'tundu' disease of wheat, has so far been reported to remain viable in two and a half year old ear cockle galls (Cheo, 1946) incited by *Anguina tritici*, (Steinbuch) Filipjev with which the bacterium is known to be transmitted. (Swaroop and Singh, 1962, Vasudeva and Hingorani, 1952). The present study was conducted to determine whether the bacterium *C. tritici* can remain viable in nematode galls for more than the reported period. The ear cockle galls collected after wheat harvest, 1958–1962 were stored in the laboratory until October, 1962 and were used as a source of infection. Seeds of Pb 591 variety were mixed with the nematode galls in equal numbers and were sown in 8 ft. rod rows replicated 5 times. In order to avoid possible mixing of inoculum through rain and irrigation water from one plot to another, 1·5 ft. ridges were made to separate the plots, which were irrigated twice every month in order to ensure maximum infection. (Vasudeva, 1958). At the time of maturity, data on the incidence of both bacterial and nematode diseases were taken on ear basis in each plot. The data are summarised in Table 1.

TABLE 1

Showing the viability of Corynebacterium tritici in ear cockle galls of different ages

Nematode galls collected in	Percentage of ears affected with	
	Bacterial disease	Ear cockle
1958	1·1	0·8
1959	3·6	2·4
1960	3·4	2·6
1961	23·0	10·2
1962	28·2	9·1
Control (no galls)	nil	nil

The crop raised from the seeds mixed with the 1958 nematode galls showed 1·1 percent bacterial affected ears, indicating that the bacterium *C. tritici* retains the viability for at least five years in the nematode galls. The incidence of the bacterial disease decreased with an increase in the age of the nematode galls. The viability of the bacteria in the nematode galls was fairly high upto two years, then it dropped abruptly in three year and older galls.

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DETERMINATION OF THE ACCUMULATION OF DDT AND BHC IN THE LIVER AND INTESTINE OF CERTAIN FISHES

By

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Introduction

An exhaustive literature on the pernicious effects of DDT in animal-body has been given by Hayes (1954). During the past several years new modes and modifications of existing methods for the determination of injuries caused by DDT have been reported (Hayes 1954). Pharmacological tests have shown that DDT accumulates in the fatty tissue of animals, because it is absorbed more easily by different tissues when in solution (Haller, 1945).

The absorption of DDT and BHC in the intestine and liver is more than that in other organs and consequently a greater part of these organs gets damaged (Mathur, 1962-63). Recently several organic insecticides have come into common use but the chemical methods for their detection in the tissues have not been developed. It has become very essential now to find out sensitive methods for the detection and measurement of the minute quantities of the common insecticides in the tissues.

Technique. Schechter-Haller's colorimeteric method (1945) for determining DDT in microquantity is now generally accepted as the best available method. Methods for the determination of small amount of DDT occurring as insecticidal residue have been reviewed by Cristol *et al* (1945). A considerable amount of difficulty is, however, experienced in the application of this method for determining relatively small amount of DDT in the fat tissue and other biological materials.

The total organic chloride method provides a fairly satisfactory analytical method for the determination of DDT absorbed in the animal tissue. Much of the analytical work on DDT has depended on chloride determination. The labile chloride method determines only one chlorine atom per molecule of DDT, whereas the total organic chloride method determines five atoms per molecule. Difficulties are faced in the determination of chlorine in both these methods and specificity is lacking when the amount of DDT is less than 1 gm. (Schechter and Haller, 1945).

In this work labile chlorine and total organic chlorine methods recommended by Wichmann have been used to detect the accumulation of DDT and BHC in the fish tissue.

Observations

(a) *Labile chlorine method.* In a trough containing 3500 cc. of water one *Ophicephalus punctatus* was kept, 1 cc. of 25% DDT emulsion was sprayed. The fish died in 48 hours. The liver and the intestine were taken out. They weighed 1·300 gm. and 5 gm. respectively. These were cut into very small pieces and dissolved in Petroleum ether. The solution was treated with 2N alcoholic KOH.

In this reflux solution, 10 ml. of dil. HNO_3, 10 ml. of $AgNo_3$ and 5 cc. of ferric alum was added. It was titrated by Volhard's method with N/10 KCNS. The end point was the appearance of red ferric thiocynate colour. 0·0083 gm. of DDT was found in both the intestine and the liver of the killed fish at a concentration of 1 cc. of 25% DDT emulsion.

In another experiment 5 liter of water was taken in a small aquarium and one *Ophicephalus punctatus* was kept in it. When 5 cc. of 25% DDT emulsion was sprayed, the fish died in 2 hours. The liver and the intestine were taken out, cut into small pieces and churned into liquid form. These were dissolved in Petroleum ether and the solution was kept for a few hours. Titration was done as in the previous case. In this fish, 0·1344 gm. of DDT was present in the intestine and 0·1292 gm. in the liver.

In another investigation, it was found that one *Barbus stigma* died in 2 hours and 30 minutes when DDT emulsion of the same strength was sprayed in a small jar containing two liter of water. 0·06523 gm. of DDT was discovered in the liver and 0·07799 gm. in intestine of the fish.

(*b*) *Organic chloride method.* In a small battery jar 5 liters of water was taken and one *Heteropneustes fossilis* was kept. 25 cc. of BHC (20%) was sprayed. The fish died in one hour and thirty minutes. Liver and intestine were taken out. Each of them weighed 120 gm. They were cut into very small pieces, churned into liquid form and dissolved in Benzene. The solution was kept for 24 hours.

Later on it was refluxed for two hours with metallic sodium and 20 ml. of isoproponol. The chloride was determined by Volhard's method. In this reflux solution 20 ml. of dil. HNO_3, 20 ml. of N/10 $AgNo_3$ and 5 cc. of ferric alum were added. After shaking well, it was titrated with N/10 KCNS solution. The end point was the appearance of red ferric thiocynate colour. The fish contained 0·01772 gm. of BHC in intestine and 0·012053 gm. in liver.

Summary

1. DDT and BHC solutions kill the fish at various concentrations due to the absorption of these insecticides in liver and intestine.

2. In the affected fishes, *Ophicephalus punctatus*, *Heteropneustes fossilis* and *Barbus stigma*, the microquantity of absorbed DDT and BHC has been determined by labile chlorine and organic chloride methods.

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POST HARVEST DISEASES OF SOME FRUITS AND VEGETABLES

By

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Fruits and vegetables are subject to a number of diseases during transit, storage and marketing. During the last two years the authors isolated a number of fungi from infected fruits and vegetables, obtained from the local markets. In the present paper a list of the fungi isolated from 33 fruits and vegetables is presented. The list includes only those fungi which were repeatedly isolated. The type of symptoms produced by them has also been mentioned. All the new host records for India have been marked with an '*'. Pathogenicity was tested and those which were merely associated with the host but did not show any parasitic characters have been indicated by a '+' sign.

Infected fruits were collected from the local markets and were brought to the laboratory. The fruits were surface sterilized with 90% ethanol, and a few pieces cut from the junction of the healthy and diseased tissue were transferred to the P. D. A. slants. The isolates were subsequently purified by the usual methods. To ascertain the identity of the various fungi they were studied both under natural as well as cultural conditions.

The various fungi isolated from different fruits and vegetables during the course of investigations are listed below :

No.	Host	Fungi	Symptoms
1.	*Ananas cosmosus* Merr. (Pine apple ; Vern. *Ananas*) Family : Bromeliaceae.	*Trichothecium roseum* Link ex Fr.	Pink rot
		Geotrichum candidum Link ex Pers.	Soft rot
2.	*Anona squamosa* L. (Custard apple ; Vern. *Shareefa*) Family : Anonaceae	*Botryodiplodia theobromae* Pat.	Soft rot
		Colletotrichum anonicola Speg.	Anthracnose
		+*Curvularia lunata* (Wakker) Boed.	—
		Thielaviopsis paradoxa (De Seyn.) Höen.	Black rot
3.	*Artocarpus lakoocha* Roxb. (Vern. *Barhal*) Family : Urticaceae	*Alternaria tenuis* Nees	Dry rot
4.	*Averrhoa carambola* L. (Carambola ; Vern. *Kamarakh*) Family : Geraniaceae	*Botryodiplodia theobromae* Pat.	Soft rot
		Colletotrichum gloeosporioides Penz.	Anthracnose
		Phomopsis sp.	Soft rot
5.	*Brassica oleracea* L. (Cauliflower ; Vern. *Gobhi*) Family : Cruciferae	*Alternaria tenuis* Nees	Brown rot
		Fusarium semitectum Berk. et Rav.	Pink rot
		+*Trichothecium roseum* Link ex Fr.	—

No.	Host	Fungi	Symptoms
6.	Capsicum frutescens L. (Chilly ; Vern. Mirch) Family : Solanaceae	Alternaria tenuis Nees Colletotrichum capsici (Syd.) But. et Bisby *Fusarium semitectum Berk. et Rav.	Black rot Anthracnose Pink rot
7.	Carissa carandus L. (Carandus ; Vern. Karonda) Family : Apocynaceae	*Colletotrichum dematium (Pers. ex Fr.) Grove *Fusarium semitectum Berk. et Rav.	Anthracnose Soft rot
8.	Citrus aurantium L. (Orange ; Vern. Santara) Family : Rutaceae	*Alternaria tenuis Nees Botryodiplodia theobromae Pat. *+Nigrospora oryzae (Berk. et Br.) Petch	Brown rot Soft rot –
9.	Citrus medica L. var. medica (Lemon ; Vern. Nibu) Family : Rutaceae	*Botryodiplodia theobromae Pat. Fusarium semitectum Berk. et Rav. Glomerella cingulata (Stonem.) Spauld and Schrenk	Brown rot Soft rot Anthracnose
10.	Citrus sinensis Osbeck. (Vern. Musambi) Family : Rutaceae	Alternaria citri Pierce *Botryodiplodia theobromae Pat.	Black rot Soft rot
11.	Cocos nucifera L. (Coconut ; Vern. Gari) Family : Palmae	*Alternaria tenuis Nees *Curvularia lunata (Wakker) Boed.	Brown rot Gray mold
12.	Cucumis melo L. (Cucumber ; Kheera) Family : Cucurbitaceae	*Alternaria tenuis Nees *Curvularia lunata (Wakker) Boed. Fusarium sp.	Brown rot Brown rot Soft rot
13.	Daucus carota L. (Carrot ; Vern. Gajar) Family : Umbelliferae	Fusarium oxysporum Fr.	Soft rot
14.	Dolichos lablab L. (Bean ; Vern. Sem) Family : Leguminosae	*Alternaria tenuis Nees	Black rot
15.	Eriobotrya japonica Lindl. (Loquat , Vern. Loquat) Family : Rosaceae	*Alternaria tenuis Nees Botryodiplodia theobromae Pat. Fusarium roseum Link +*Malustela aeria Batista et al. *Pestalotia versicolor (Speg.) Stey.	Black rot Soft rot Soft rot . – Soft rot
16.	Ficus glomerata Roxb. (Fig ; Vern. Gular) Family : Urticaceae	*Chaetomium venezuelense Ames. *Curvularia lunata (Wakker) Boed.	Surface rot Surface rot

No.	Host	Fungi	Symptoms
17.	*Hibiscus esculentus* L. (Lady's finger ; Vern. *Bhindi*) Family : Malvaceae	**Fusarium scirpi* Lamb. et Fantr.	Slimy rot
18.	*Lagenaria leucantha* (Dutch) Rusby (Bottle gourd ; Vern. *Lauki*) Family : Cucurbitaceae	**Alternaria tenuis* Nees	Brown rot
		*Cladosporium herbarum (Pers.) Link	Surface rot
		*Fusarium semitectum Berk. et Rav.	Soft rot
		+**Macrophomina phaseoli* (Maubl.) Ashby	—
19.	*Luffa acutangula* Roxb. (Ribbed gourd ; Vern. *Taroi*) Family : Cucurbitaceae	+**Chaetomium globosum* Kunze et Schm.	—
		+**Curvularia lunata* (Wakker) Boed.	—
		Fusarium semitectum Berk. et Rav.	Soft rot
20.	*Luffa cylindrica* Roem. (Loofah ; Vern. *Nenua*) Family : Cucurbitaceae	**Cladosporium herbarum* (Pers.) Link	Surface rot
		*Geotrichum candidum Link ex Pers.	Soft rot
		*Fusarium semitectum Berk. et Rav.	Soft rot
21.	*Lycopersicon esculentum* Mill (Tomato ; Vern. *Tamatar*) Family : Solanceae	**Alternaria tenuis* Nees	Black rot
		Cladosporium fulvum Cooke	Surface rot
		*Colletotrichum dematium (Pers. ex Fr.) Grove	Anthracnose
		Fusarium roseum Link	Soft rot
		*Malustela aeria Batista *et al.*	Soft rot
		+**Melanospora damnosa* (Sacc.) Lind.	—
		*Myrothecium roridum Tode ex Fr.	Ring rot
22.	*Mimusops hexandra* Roxb. Vern. *Khirni* Family : Sapotaceae	**Alternaria tenuis* Nees	Black rot
		*Botryodiplodia theobromae Pat.	Soft rot
		*Pestalotia versicolor (Speg.) Stey.	Soft rot
23.	*Phoenix acaulis* Roxb. (Date ; Vern. *Khajur*) Family : Palmae	**Fusarium scirpi* Lamb. et Fantr.	Dry rot
24.	*Phyllanthus emblica* L. (Emblic myrobalan ; Vern. *Anvala*) Family : Euphorbiaceae	**Aspergillus awamori* Naka-zava	Surface rot
		*Aspergillus niger van Tiegh.	Surface rot
		Penicillium sp.	Surface rot
		*Pestalotia cruenta Syd.	Dry rot
		*Phoma sp.	Dry rot

No.	Host	Fungi	Symptoms
25.	*Physalis peruviana* L. (Goseberry ; Vern. *Makoy*) Family : Solanaceae	*Alternaria tenuis* Nees *Fusarium semitectum* Berk. et Rav.	Brown rot Soft rot
26.	*Pisum sativum* L. (Pea ; Vern. *Matar*) Family : Leguminosae	*Alternaria tenuis* Nees *Cladosporium sphaerospermum* Penzig	Brown rot Gray scab
27.	*Prunus persica* Stokes (Peach ; Vern. *Aru*)	*Fusarium* sp. *Sordaria* sp.	Soft rot Soft rot
28.	*Pyrus communis* L. (Europ. pear ; Vern. *Nakh*) Family : Rosaceae	*Physalospora obtusa* (Schw.) Cooke	Soft rot
29.	*Pyrus malus* L. (Apple ; Vern. *Sev*) Family : Rosaceae	*Aspergillus niger* van Tiegh *Botryodiplodia theobromae* Pat. +*Curvularia spicifera* (Bainier) Boed. *Penicillium expansum* Link	Soft rot Soft rot – Soft rot
30.	*Pyrus sinensis* Lindl. (Pear. Vern. *Nashpati*) Family : Rosaceae	*Aspergillus niger* van Tiegh *Botryodiplodia theobromae* Pat.	Soft rot Soft rot
31.	*Solanum melongena* L. (Brinjal ; Vern. *Baigan*) Family : Solanaceae	*Alternaria tenuis* Nees *Curvularia lunata* (Wakker) Boed. *Fusarium solani* (Mart.) App. et Wollen. *Fusarium roseum* Link	Black rot – Dry rot Tip end rot
32.	*Trichosanthes dioica* Roxb. (Vern. *Parval*) Family : Cucurbitaceae	*Fusarium* sp. *Macrophomina phaseoli* (Maubl.) Ashby	Soft rot –
33.	*Zingiber officinalis* Rosc. (Ginger ; Vern. *Adarakh*) Family : Scitamineae	*Sclerotium rolfsii* Sacc.	Soft rot

In all 22 genera of fungi were isolated, of them species of *Fusarium* were most common. They were followed by *Alternaria* and *Botryodiplodia*. Further work on physiology and pathogenic behaviour of the above isolates is under progress.

PATHOLOGICAL STUDIES OF *PESTALOTIA BICOLOR* ELL. ET EV. CAUSING LEAF SPOT DISEASE OF *DIOSPYROS PEREGRINA* (GAERTN.) GURKE

By

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The leaves of *Diospyros peregrina* were found to be severely attacked by *Pestalotia bicolor*, in the Botanical garden of Allahabad University. This plant is of medicinal importance. The authors, therefore, undertook pathological investigations on the organism responsible for causing the leaf spot disease.

Material and Method

The culture of the pathogen was the same as used for physiological studies carried out by Lal (1963). Leaves of three different ages of *Diospyros peregrina* (*viz.* very young, young and old) were used for pathogenicity tests. Both injured and uninjured surfaces of the leaves were employed for artificial inoculations. Various methods of inoculations were tried but the mass inoculation method was found to be most effective, and it was, therefore, used for detailed studies. Controls were maintained in each case. In order to confirm that the infection was caused by the organism, reisolations were always made from the diseased lesions. Before inoculation the surfaces of the leaves were washed with sterilized distilled water and subsequently treated with 90% alcohol. Very superficial injury was inflicted with the help of a sterilized needle. Cross inoculations were also made on the leaves of other plants as well as on fruits and vegetables. Ridgway's (1912) 'Color standard and Color nomenclature' was used for the determination of various colours.

Observations

(a) *Symptoms of the disease on leaves.* At the initial stages of incubation the diseased regions showed discoloration. As the spots increased they assumed Pale Ochraceous Buff colour in the centre and developed irregular shape. At this stage the boundary of the infected region showed an outer thin zone of Blackish Mouse Gray colour. The inner zone was, however, broader than the outer zone and had Chaetura Drab colour. On the lower surface of the leaf the spot had a light Buff colour.

Lateral veins around the infected region had Blackish Mouse Gray colour. The acervuli developed as small blackish bodies all over the surface of the infected area. At maturity they were slightly raised from the surface (fig. 1). At an advanced stage of the disease the spots enlarged considerably and occupied a large area of the leaf.

(b) *Symptoms on fruits.* It also caused a rot of fruits. The irregular rotten area increased very soon. The colour of the infected part changed to Antimony Yellow with an outline of Dark Olive Buff. The rotten flesh of the fruit was brownish, softer than the healthy portion, but it was not watery.

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Isolations from the diseased areas invariably yielded *Pestalotia bicolor*, which showed the following morphological characters :

Hyphae thin, hyaline, septate, branched, 2·0–2·3μ thick ; spores produced inside the acervuli, mostly four septate, terminal cells hyaline with pointed apex, one of the end cells with 3 hyaline appendages, the other three cells Olive Buff, average size ranged from 23·0×6·9μ–18·4×5·75μ ; chlamydospores rarely developed in chain ; acervuli of very variable shape and size, with a peripheral sheath of closely packed parenchymatous cells. The middle part of the acervuli had a mass of spores (fig. 2).

The pathogenicity of *Pestalotia bicolor* on the leaves of *Diospyros peregrina* was tested. The organism was inoculated by mass inoculation method. Moisture was provided to the inoculum by placing moist cotton pads. It was found that only injured leaves developed the infection. There was no difference in percentage of infection from the lower or the upper surface of the leaf. The percentage of infection showed variation in leaves of different ages. This was 50, 80 and 100 for very young, young and old leaves respectively. During the experiment it was also observed that not only the percentage of infection but the time of the symptoms also varied with the age of the leaves. The disease symptoms appeared earlier on the older leaves than on the younger ones. Frequency of fruiting bodies was also greater on the older leaves.

Microtome sections through the infected tissues of the host showed that hyphae were both inter and intracellular. Pseudopycnidia with numerous spores of the pathogen were developed in the mesophyll region.

The effect of temperature on the germination of spores was also studied. The following temperatures were used :

$$- 2°C, 10°C, 25°C, 30°C, \text{ and } 40°C.$$

It was found that the best germination was at 25°C. The spores failed to germinate at – 2°C, 10°C and 40°C. The thermal death point was found to be 53°C.

Host Range

Pestalotia bicolor was inoculated on the leaves of the following plants with and without injury. It was found that the leaves of *Mangifera indica*, *Eugenia jambolana*, *Madhuca latifolia*, *Citrus medica*, *Rosa* sp., *Musa paradisiaca*, *Canna indica*, *Ficus religiosa*, *Pesidium guajava* and *Caryota mitis* were infected but previous injury was essential. There was no infection in *Ficus* sp. and *Muehlenbeckia platycladus*. Some fruits and vegetables were also inoculated. *Lycopersicum esculentum*, *Litchi chinensis*, *Musa paradisiaca* and *Mimusops elangi* were injured by pin prick method while others by Granger and Horne's (1924) method. The fruits of *Solanum melongena*, *Litchi chinensis*, *Trichosanthes dioica* (fig. 3) and *Musa* sp. were found to be susceptible while *Mangifera indica*, *Momordica charantia*, *Carica papaya*, *Mimusops elangi*, and *Citrus suntara* were not infected.

Evaluation of fungicides

Forsberg (1949) suggested an effective and simple method for the evaluation of fungicides which has been followed in the present investigation. Those fungicides were considered ineffective where growth appeared. The results of treatment with fungicides are given in Table 1.
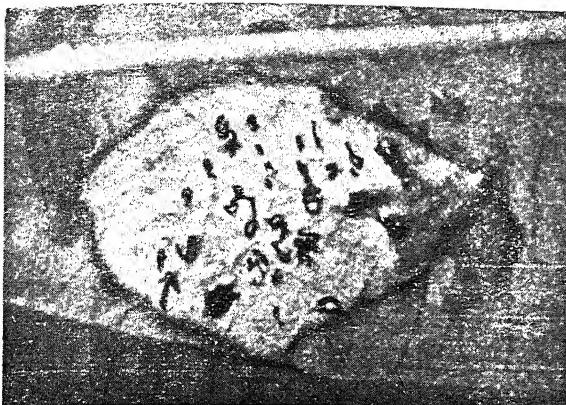
Fig. 1. Showing an elnarged view
of the infected spot of
Diospyros peregrina leaf.

Fig. 2, Showing rots of :
1. Trichosanthes dioica
2. Solanum melongena
3. Litchi chinensis
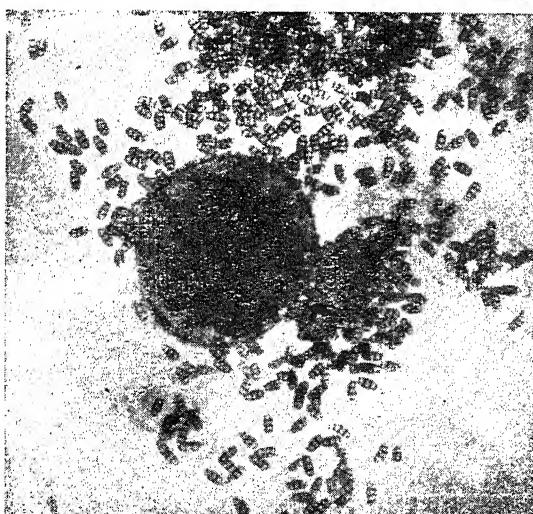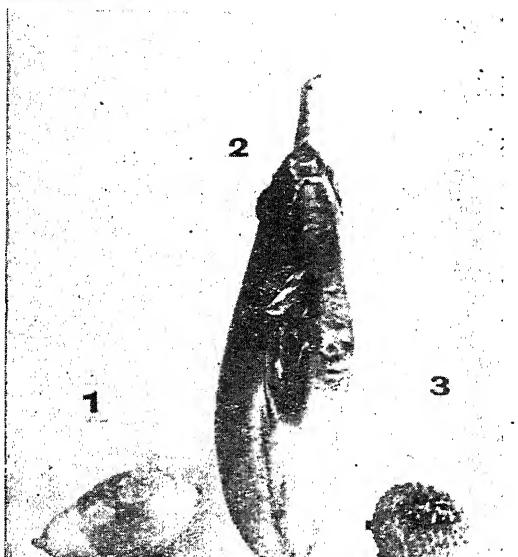
Fig. 3. Microphotograph showing
acervuli with spores of
Pestalotia bicolor.

TABLE 1

Showing the effect of different fungicides on the growth of Pestalotia bicolor.

Fungicides	Growth of the fungus after 24 hours				
	1st day	2nd day	3rd day	4th day	5th day
1. Copper sandoz	−	−	−	−	−
2. Blitox	−	−	+	+	+
3. Cupravit	−	−	−	+	+
4. Dithane Z–78	−	−	−	+	+
5. Micop W–50	−	−	−	+	+
6. Cupramar	−	−	−	+	+
7. Flit 406	−	−	−	−	−
8. Zerlate	−	−	+	+	+
9. Kirti copper	−	−	−	−	−
10. Onyxide –75%	−	−	−	+	+
11. U. N. R. 50%	−	−	−	−	−
12. Isothane Q–15	−	−	+	+	+

+Indicates the presence of growth.
— „ „ absence of growth.

The above table clearly indicates that among the solid fungicides, Copper sandoz, Flit 406 and Kirti copper inhibited the growth, while Blitox, Zerlate, Cupravit, Dithane Z–78, Micop W–50 and Cupramar could not check it. U. N. R. 50% was the only liquid fungicide which could prevent the growth while Onyxide 75% and Isothane Q–15 failed to do so.

Both the solid and liquid fungicides which were found to be effective in controlling the growth of the organism under laboratory condition were dusted or sprayed on the leaves of *Diospyros peregrina* at different intervals before or after inoculation. Their effect on the appearance of the disease was then recorded. It was observed that Kirti copper and Copper sandoz completely failed to check the spread of disease. U. N. R. 50% and Flit 406 could prevent the infection if they were applied within two days of inoculations. These fungicides could also check the spread of disease when the inoculations was made just before application of the fungicides.

Discussion

The present isolate of *Pestalotia bicolor* was pathogenic to *D. peregrina* and could easily infect the leaves of *Mangifera indica*, *Eugenia jambolana*, *Madhuca latifolia*, *Citrus medica*, *Rosa* sp., *Musa paradisiaca*, *Canna indica*, *Ficus religiosa*, *Psidium guajava* and *Caryota mitis* if these were inoculated after injury. The leaves of *Ficus* sp. and phylloclades of *Muehlenbeckia platycladus* were not infected even after injury. Tandon, Sisodia and Bilgrami (1955) have reported that *Pestalotia mangiferae* could not infect the leaves of *Psidium guajava*, *Mimusops hexandra*, *Butea frondosa*, *Eucalyptus* sp. and *Citrus* sp. which shows that pathogenic nature of different species of *Pestalotia* varies with hosts. *Pestalotia bicolor* was also found to cause rot of several fruits

and vegetables *e.g., Diospyros peregrina, Litchi chinensis, Solanum melongena, Trichosanthes dioica* and *Musa paradisiaca.* It is thus clear that the organism under investigation is pathogenic to some and not to other hosts. In this respect its behaviour is similar to *Pestalotia mangiferae,* which was parasitic to *Mangifera indica* but had no effect on fruits of guava, apple, banana, 'Nakh', 'Naspati'.

A temperature of 25°C was found to be the best for spore germination of the present isolate. Srivastava (1955) however, reported that 30°C was the best temperature for the germination of spores of *Pestalotia* sp. studied by him. Mitra (1961) mentioned that 20°C was the best temperature for the germination of spores of *Pestalotia* sp. causing leaf spot disease of *Eugenia jambolana.*

Thermal death point of the organism was found to be 53°C and 52°C when it was exposed for two minutes and five minutes respectively. Bilgrami (1956) found that the thermal death point of *Pestalotia mangiferae* was 57°C if the exposure was for two minutes. He further observed that if the time of exposure was increased to five minutes, the organism was killed at 55°C. Bhargava (1958) reported that thermal death point of *Pestalotia* sp. isolated from *Livistona rotundifolia* and *Pestalotia theae* isolated from *Thea sinensis* were 56°C and 55°C respectively when they were exposed to these temperatures for one minute. Thus thermal death point of the present organism was lower than that of the species mentioned above.

Out of a number of fungicides which were found to be effective in the laboratory (Kirti copper, Flit 406, Copper sandoz and U. N. R. 50%) only Flit 406 and U. N. R. 50% were successful in controlling the disease provided they were applied upto two days before or after inoculation. Tandon, Sisodia and Bilgrami (1955) have reported that dusting the leaves with zinc sulphate controlled the disease caused by *Pestalotia mangiferae* but dusting on fruits failed to control the rot.

Summary

Pathogenicity of *Pestalotia bicolor* was established on the leaves as well as fruits of *Diospyros peregrina.* All the leaves which were injured either from lower or upper surface sustained infection. The older leaves were found to be more susceptible to the disease than the younger ones. The microtome section through the infected tissues of the host showed that hyphae were both inter and intracellular. Cross inoculations showed that the organism could infect the leaves of *Mangifera indica, Eugenia jambolana, Madhuca latifolia, Citrus medica, Rosa* sp., *Canna indica, Ficus religiosa, Psidium guajava* and *Caryota mitis,* but it failed to infect *Ficus* sp. and the phylloclades of *Muehlenbeckia platycladus. Pestalotia bicolor* could also cause the fruit rot of *Solanum melongena, Litchi chinensis, Trichosanthes dioica* and *Musa paradisiaca* but it could not infect *Mangifera indica, Citrus suntara, Momordica charantia, Carica papaya, Mimusops elangi* and *Lycopersicum esculantum.*

Laboratory evaluation of fungicides showed that Copper sandoz, Flit 406, Kirti copper and U. N. R. 50% could inhibit the growth of the fungus. Trials of fungicides in field conditions revealed that Kirti copper and Copper sandoz completely failed to check the spread of disease. U. N. R. 50% and Flit 406 could check the spread of disease if inoculum was placed upto two days after or just before the application of the fungicide.

Germination of the spores of *Pestalotia bicolor* was best at 25°C. Thermal death point of the organism was 53°C, when it was exposed for two minutes.

Acknowledgements

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STUDIES IN ANTIBIOSIS BETWEEN SOIL ACTINOMYCETES AND FUNGI IN VITRO

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Literature on the control of plant diseases by use of antagonistic organisms has been reviewed by Wood and Tveit (1955). The screening of soil microorganisms antagonistic to the pathogen with a view to reduce or even completely suppress its growth for the possibilities of checking disease production, could initially be profitably made in vitro, so as to give a clue to their antagonistic value for testing them in vivo. The degree of inhibition of a particular soil isolate differs with the fungus pathogen tested (Landerkin, Smith and Lochead, 1950). The present paper gives an account of in vitro studies of screening of actinomycetes isolated from Rajasthan soil for their antagonistic properties against soil fungi.

TABLE I

Comparative antagonistic activity of Streptomyces species against various soil fungi represented as inhibition zones in mm.

Antagonistic organism	Test organisms							
	A	B	C	D	E	F	G	H
S. anulatus	7·0	3·5	6·0	+	14·5	3·0	6·0	15·0
S. aureofaciens	5·5	3·0	9·0	−	12·5	5·5	2·0	15·0
S. bikiniensis	2·5	2 5	2·5	−,	5·0	−	4·5	10·0
S. cylindrosporm	7·0	4·5	2·5	7·5	3·5	4·5	−	17·5
S. fasciculus	11·5	8·5	9·5	5·5	6·5	10·5	11·5	15·0
S. fumosus	2·5	3·5	2·5	−	4·0	−	4·5	9·5
S. griseolus	5·5	4·5	5·0	−	2·5	1·5	−	9·5
S. griseoflavus	4·0	2·0	3·5	2·0	8·0	2·5	8·5	9·5
S. phaeochromogenus	9·0	5·5	8·5	8·5	6·5	6·5	1·5	−
Unidentified	3·5	3·0	1·0	−	2·5	3·0	3·5	4·5
,,	5·5	2·5	+	−	2·5	−	−	7·5

Note. A—*Fusarium oxysporum* f. *cumini,* B—*F. o.* f. *coriandrii,* C—*F. solani,* D—*F.* sp. from soil, E—*Curvularia lunata,* F—*Sclerotium* sp., G.—*Pythium* sp., H—*Alternaria tenuis.*
+ = Positive inhibition, − = Negative inhibition.

Soil samples were collected up to a depth of six inches from cultivated fields after scraping surface layer and stored in petriplates after drying. Dilutions up to 10,000 were made on Thornton's agar and potato dextrose agar media. The

actinomycetes thus isolated were purified and sub-cultured on potato dextrose agar or peptone agar for further use. To study their antagonistic effect, the actinomycetes were streaked on one side of potato dextrose agar plate and the test organism seeded on the other side of the plate and were incubated at room temperature for about a week and inhibition zone measured.

In preliminary screening tests, using *Alternaria tenuis* as a test organism, actinomycetes showing antagonistic properties were selected and put to test against other soil fungi. Most of the species tested exhibited strong inhibitory effect against *Alternaria tenuis* and *Curvularia lunata* (Table I). Amongst the active strains, some have shown good inhibitory effect against *Fusarium* sp., where as they were less active against *Pythium* sp. and *Sclerotium* sp. At the edge of inhibition zones, various morphogenic effects were seen. *S. fasciculus* induced abnormal branching and club shaped hyphal tips, where as *S. cylindrosporum* caused heavy chlamydospore formation. In *Alternaria tenuis* the spores lost their characteristic beak and became more or less rounded with one or two cross septa. In other cases, occasionally isolated hyphae grew into the intervening zone, but with this exception the growth of the pathogen sooner or later stoped. Most of the highly antagonistic species showed their activity against all fungi tested. Some of the non-antagonistic species to *Alternaria tenuis* were antagonistic to other fungi.

TABLE II

Comparative antagonistic activity of Streptomyces anulatus *isolates against various soil fungi*

Streptomyces anulatus isolates	Inhibition zones in mm							
	A	B	C	D	E	F	G	H
S. 1	7·0	3·5	6·0	+	14·5	3·0	6·0	15·0
S. 2	6·5	3·0	2·0	1·5	10·5	2·5	4·0	8·0
S. 3	6·0	4·5	2·0	–	7·5	3·0	2·5	6·0
S. 7	9·0	5·0	5·5	–	9·5	2·0	7·5	17·0
S. 9	8·0	6·5	8·5	–	11·0	3·0	5·5	15·0
S. 12	7·0	7·5	3·0	3·5	12·0	3 5	5·5	14·5
S. 13	6·0	5·5	4·5	–	12·5	3·5	2·5	14·0
S. 21	7·0	3·5	6·5	–	12·5	4·5	2·5	14·0
S. 22	6·5	3·5	3·0	1·5	11·0	–	7·5	12·5
S. 23	8·0	5·5	5·0	–	11·5	2·5	4·5	16·5
S. 24	–	10·5	3·5	–	–	4·5	–	–
S. 25	6·0	5·5	4·0	2·0	11·0	4·5	8·5	14·5
S. 28	5·5	2·0	–	–	1·5	–	–	4·5
S. 29	9·5	6·5	3·5	2·0	9·5	1·5	3·5	9·5

Landerkin *et al* (1950) reported that percentage of active cultures was greater and the degree of inhibition much more marked against *Curvularia* than against *Fusarium oxysporum* and *Fusarium solani*. Out of a large number of antago-nistic streptomyces sp. tested by Mukerjee and Nandi (1955) only one was

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antagonistic to *Fusarium*, 15 against *Alternaria solani*, 17 against *Curvularia speciferae*. Johnson (1952) isolated from soil actinomycetes showing high spectrum against *Pythium arrhenomanes*. Chi (1960) studied the effects of 11 species of streptomyces of *Fusarium oxysporum* and *F. roseum*. All were antagonistic to each of the *Fusarium* sp. and produced similar effects but differed considerably in the degree of inhibition incited. Although most of the species of streptomyces under study produced fairly good inhibition zones against *Fusarium oxysporum* f. *cumini*, and *F. o.* f. *coriandrii*, and *F. solani* and very poor against *F.* sp., some species were more antagonistic to cumin wilt *Fusarium* in comparison with coriander wilt *Fusarium*. Buxton and Richards (1955) distinguished various form of *Fusarium oxysporum* by their differential tolerance to inhibition by various actinomycetes which could not be verified in present studies.

Different isolates belonging to the same species possessed different antagonistic properties (Table II). Similar results were obtained by Mukerjee and Nandi (1955).

Acknowledgement

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CONTRIBUTION TO THE PLANT ECOLOGY OF ARAVALLI HILLS
## 3—VEGETATION OF KUMBHALGARH

By

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Introduction

The topography of Rajasthan is dominated by the Aravalli mountains, stretching in a south-west to north-east direction from Champaner in Gujrat to near Delhi. Important contributions on the vegetation of Aravalli hills are those of King (1879), Sutaria (1941), Ratnam (1951), Raizada (1954), Nair and Nathawat (1957), Sharma (1958), Jain and Kotwal (1960), Mathur (1960), Mulay and Mathur (1961), Nair (1961), Nair, Kanodia and Thomas (1961), Puri and Jain (1961), Jain (1962), Kanodia and Deshpande (1962), Vyas (1962 and 1963), Ramdeo (1963), Rolla and Kanodia (1963) and Vyas and Ramdeo (1964). These investigations include localities like Ajmer, Alwar, Harshnath, Jaipur, Jodhpur, Khetri, Lohargal, Mount Abu, Shahabad, Tonk and Udaipur.

(Map showing Location of Udaipur Division in Rajasthan.)
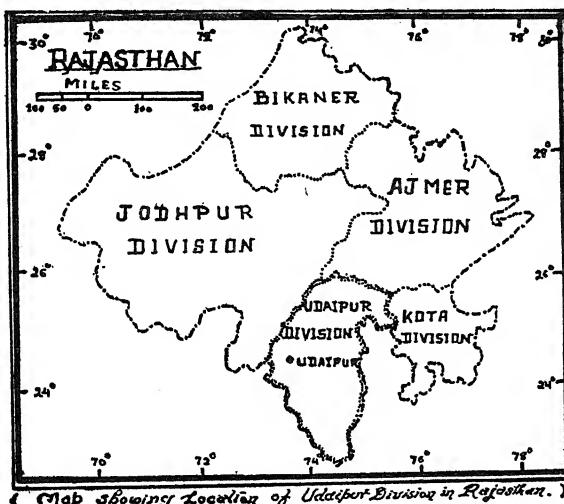
A perusal of the literature at hand reveals that only few spots in north-east Rajasthan have been properly investigated and there is enough scope for the study of vegetation of Aravalli hills. In spite of the fact that south-eastern Rajasthan, due to its higher altitude and rain fall, supports better vegetation, it has been sadly neglected. The only account of flora of this tract is that of Udaipur and its neighbourhood (Ramdeo, 1963).

The present work deals with the vegetation of Kumbhalgarh, a famous fort on one of the highest peaks of Aravallis. There is presumably no information about

the vegetation of this area. The time at authors' disposal being insufficient, the present study aims to record the persent floristic and ecological features of the vegetation, so as to provide a basis for comparison at some future date.

Physiography and Geology

The historic fort of Kumbhalgarh (25·9'N and 73·35'E) is situated in the heart of the main Aravalli ranges along western flank nearly 75 Km. north of Udaipur City and at an altitude of 910 m. It commands a spectacular view of, (i) the vast sandy plains of Marwar in the west, (ii) the narth-east to south-west streak of parallel ranges of Aravalli in the middle, and (iii) the uneven rolling plains of Mewar in the east.

The highest point in this area—the Badal Mahal is 1067 m. above sea level. The fort is surrounded by high hills. The inner region comprising more or less an undulating terrain and level flats and fields inside this naturally fortified area are under agriculture. Rocky out crops, precipitous crags and projected spurs dominate the general wilderness of this region.

The south-west portion of fort near the Badal Mahal area, gives rise to two important streams which surround the fort on all sides and finally, fall into Sukri River.

The geological structure comprises the rock formations belonging to Delhi quartizites which form the central axis of Aravallis.

Climate

The climatic data are available only for the close by station Kelwara. The climate is of Monsoon type. The average annual rainfall is 716 mm. Most of it is due to south-west monsoon. Table1 1 gives the total annual and average monthly rainfall for the last five years. The period of four months March to June is almost dry characterized by low relative humidity, increased wind velocity and high temperatures.

TABLE 1

Total annual rainfall 1959-63			Average monthly rainfall 1959-63		
Year	Rainfall in mm.	Remarks	Month	Rainfall in mm.	Remarks
1959	1070	Maximum	January	0·00	No rain
1960	580	...	February	2·54	
1961	810	...	March	2·83	
1962	605	...	April	0·00	No rain
1963	517	Minimum	May	20·41	
			June	89·14	
			July	257·51	Maximum
			August	197·03	
			September	130·42	
			October	13·01	
			November	2·37	
			December	1·23	Minimum

The winters are cool and the temperatures in early morning hours touch even freezing points. Dense frost and destructive fog may, at times, descend or develop upon the stream side which destory the crop and vegetation. The water table in the valleys varies from 4·5 m. during rainy and winter seasons to 10·5 m. in the summer.

Soil

On the hills the soil supporting plant growth consists of small pieces of gravel and rock. In the valleys and near villages the soil varies from sandy loam to clay-loam. Such soils have rich humus content, colour ranging from brown to black and pH value on the alkaline side.
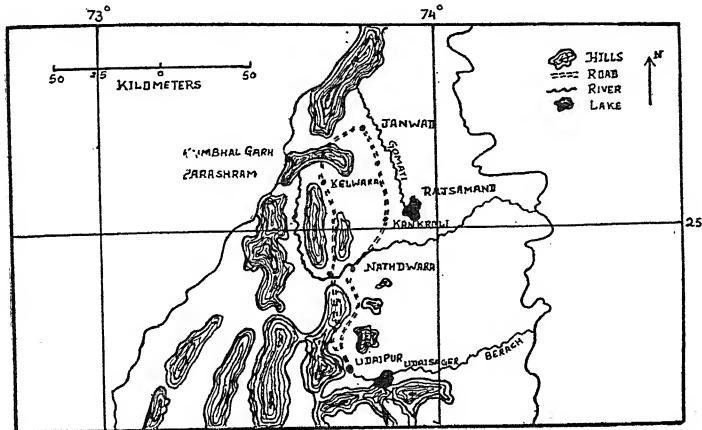
Map showing location of Kumbhalgarh

Vegetational aspect

The vegetation of Kumbhalgarh area shows a striking difference from that of neighbouring plains and comprises a variety of plant species. The forest cover is fairly dense during the monsoon months. The hot season is favourable for the flowering of woody species while large number of herbs and shrubs flower in the rainy season.

For the purpose of describing the vegetation of this area, the authors have used the following classification.

1. Vegetation of hills.
2. Vegetation of valleys.
3. Vegetation of aquatic habitats.
4. Ruderals.

1. *Vegetation of hills*

The vegetation of hills shows a distinct zonation starting from the base and culminating towards the top. The species can be arranged in three elevational zones. (*i*) lower (*ii*) middle (*iii*) upper.

The important perennial species of the lower zone are *Annona squamosa,* *Diospyros melanoxylon, Jatropha curcus, Adhatoda vasica* and *Dyerophyton indicum.* The herbaceous species include *Cassia tora, Acanthospermum hispidum, Barleria prionitis, Tephrosia purpurea* etc.

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In the middle zone the vegetation is dominated by *Lannea coromandelica, Acacia catechu, Acacia senegal, Wrightia tomentosa, Commiphora mukul, Euphorbia nivulia, Hamiltonia suaveolens* and *Mimosa hamata*. The under growth includes *Verbena bipinnatifida, Triumfetta rhomboidea, Tephrosia candida, Lepidagathis hamiltoniana, Lochnera pusilla* etc.

The common perennial species of upper zone are *Boswellia serrata, Sterculia urens, Anogeissus latifolia, Anogeissus pendula, Cassia fistula, Albizia odoratissima, Bauhinia racemosa,* and *Mallotus philippensis.* The ephemeral species are *Glossocardia bosvallea, Zinnia* sp., *Verbina bipinnatifida, Barleria cristata, Ocimum americanum, Indigofera linnaei, Tephrosia candida* and *Zornia diphylla.*

The common climbers and twiners are *Cissampelos pareira, Ampelocissus arnottiana, Vallaris solanacea, Asparagus ·racemosus, Cocculus hirsutus, Mucuna prurita, Cardiospermum halicacabum* and several species of *Ipomoea*.

2. *Vegetation of Valleys*

On way to Kumbhalgarh Fort, between its first and second gate, there is a moist and shady valley of about two Kilometers. This valley supports a luxuriant growth of *Anogeissus latifolia, Emblica officinalis, Acacia catechu, Mallotus philippensis, Woodfordia fruticosa* and *Hamiltonia suaveolens*. The other common species are *Butea monosperma, Boswellia serrata, Sterculia urens, Terminalia tomentosa, Albizia odoratissima, Grewia flavescens* and *Dendrocalamus strictus.*

The common shade-loving herbs are *Oxalis repens, Trachyspermum stictocarpum, Verbena bipinnatifida, Euphorbia heterophylla, Commelina salicifolia* and *Plumbago zeylanica.*

The Bryophytic and Pteridophytic vegetation is quite rich in moist and shaded valleys. This group is represented by species such as *Riccia discolour, R. billardieri, R. plana, Cyathodium* sp., *Funaria* sp., *Actiniopteris dichotoma, Adiantium caudatum* and *Marselia minuta.*

Four angiospermic parasites collected from this area are *Cuscuta reflexa, Striga gesneroides, Cistanche tubulosa* and *Dendrophthoe falcata.*

3. *Vegetation of aquatic habitats*

The hydrophytic vegetation is poor because of the absence of perennial lakes or ponds. A pond near Kelwara called Kamal talai and few other puddles support aquatic species such as *Nymphaea stellata, Potamogeton nodosus, Ceratophyllum demersum, Vallisneria spiralis, Hydrilla verticillata* and *Typha angustata.*

On the moist banks are found *Centella asiatica, Mentha viridis, Bacopa monnieri, Eclipta prostrata, Alternanthera sessilis, Phyla nodiflora, Juncellus allopecuroides, Eleocharis capitata* and *Cyperus iria.*

The higher dried up zone is occupied by *Phoenix sylvestris, Acacia nilotica, Zizyphus xylopyra, Acanthospermum hispidum* and *Xanthium strumarium.*

4. *Ruderals*

The common ruderals near Kelwara are *Argemone mexicana, Amaranthus spinosus, Trianthema portulacastrum, Solanum surattense, Datura innoxia, Tridax procumbens* and *Calotropis gigantea.*

The common crops are maize, tobacco, rice, wheat and sugarcane. The weeds of cultivated fields and irrigated gardens are *Chenopodium album, Fumaria indica, Solanum surattense, Cleome viscosa, Withania somnifera, Amaranthus gracilis, Portulaca quadrifida* and *Oxalis repens.*

Plant communities

The vegetation was studied by quadrat method as suggested by Misra and Puri (1954). The phytosociological characters noted in the field were Dominance, Frequency and Sociability (Bharucha and De Leeuw, 1957). During the present investigation the following seven plant communities have been recognised.

S. No.	Community	Locality
1.	*Annona—Euphorbia—Jatropha*	Near Kelwara, hills facing North.
2.	*Euphorbia—Jatropha—Butea*	Near Kelwara, hills facing East.
3.	*Annona—Butea—Wrightia*	Near Kelwara tank, hills facing South.
4.	*Boswellia—Bauhinia*	Hill top near Aret gate.
5.	*Anogeissus—Euphorbia*	Hill slopes near Aret gate.
6.	*Butea—Annona*	Hill base near Aret gate and Fort.
7.	*Anogeissus—Woodfordia—Emblica*	Aret Block.

The quantitative phytosociological characters of the perennial species are given in the following Table 2. In this table the numbers 1 to 7 indicate the plant communities in the sequence as above. The first figure indicates dominance, second the frequency and third the sociability.

The symbols used are explained as under :

Dominance	Frequency class	Sociability
a abundant	1. 1 to 20%	*S* Species growing singly
c common	2. 21 to 40%	*P* ,, ,, in patches
f frequent	3. 41 to 60%	*C* ,, ,, in colonies
r rare	4. 61 to 80%	*G* ,, ,, in groups
— absent	5. 81 to 100%	

TABLE 2

Phytosociological characters of Perennial species

Species	Communities						
	1	2	3	4	5	6	7
1. *Acacia catechu*	—	f3P	—	—	—	—	c3S
2. *A. ferruginea*	—	—	—	r1S	—	—	—
3. *A. leucophloea*	—	—	—	—	—	r2S	—
4. *A. nilotica*	r1S	—	—	—	—	—	—
5. *A. senegal*	—	f2S	f3S	—	f2S	—	—
6. *Achras sapata*	—	—	—	—	—	—	r2S
7. *Adhatoda vasica*	c3C	c2P	c4C	—	c3P	—	—
8. *Albizia odoratissima*	—	—	—	r1S	r2S	—	r2S
9. *Ampelocissus arnottiana*	—	—	r2S	—	—	—	f3S
10. *Annona squamosa*	a5P	f3S	a4P	—	—	a3P	—

Species	Communities						
	1	2	3	4	5	6	7
11. *Anogeissus latifolia*	–	–	–	r1S	a4P	–	a5C
12. *A. pendula*	–	–	–	–	c3P	–	–
13. *Asparagus racemosus*	–	–	–	–	–	–	r2S
14. *Balanites aegyptiaca*	f2P	–	f2P	–	–	–	–
15. *Bauhinia malabarica*	–	r1S	–	–	–	–	–
16. *B. racemosa*	–	–	–	c3S	f2S	–	–
17. *Boswellia serrata*	–	–	–	a4S	–	–	f2S
18. *Butea monosperma*	r1S	c2S	a3P	–	–	a4P	–
19. *Calotropis gigantea*	–	–	–	–	–	–	r2S
20. *Capparis decidua*	f2P	–	–	–	–	–	–
21. *C. sepiaria*	–	–	–	–	–	–	c3P
22. *Cassia auriculata*	–	–	–	–	–	c3P	–
23. *C. fistula*	–	–	r2S	–	–	–	–
24. *Clerodendrum phlomidis*	–	–	–	–	–	–	f2S
25. *Commiphora mukul*	–	–	–	r2S	–	–	–
26. *Cordia dichotoma*	r2S	r1S	–	–	–	–	–
27. *Dendrocalamus strictus*	–	–	–	f1P	–	–	f2P
28. *Dichrostachys cinerea*	–	r2S	–	–	–	r2S	–
29. *Diospyros melanoxylon*	r2S	–	–	–	–	–	–
30. *Dyerophyton indicum*	f2S	f3S	r1S	f2S	–	–	c2S
31. *Emblica officinalis*	–	–	–	–	–	–	a3P
32. *Euphorbia neriifolia*	–	–	–	r2S	a4S	–	–
33. *E. nivulia*	a3S	a5P	f2S	r1S	–	c2S	–
34. *Feronia limonia*	–	–	–	r1S	–	–	–
35. *Flacourtia indica*	–	–	r2S	–	–	–	–
36. *Grewia flavescens*	–	–	–	–	–	c2P	c3P
37. *G. tenax*	f2P	–	–	r2S	–	c3S	c2S
38. *Hamiltonia suaveolens*	–	r2S	–	–	–	–	c4P
39. *Helicteres isora*	–	–	–	–	r1S	–	–
40. *Holoptelea integrifolia*	–	–	–	–	–	–	r2S
41. *Jatropha curcas*	c2S	a3P	–	–	–	c2S	–
42. *Lannea coromandelica*	–	r2S	–	–	–	–	–
43. *Lantana camara*	–	–	–	–	c3P	–	–
44. *Mallotus philippensis*	–	–	–	–	r2S	–	f3P
45. *Mangifera indica*	–	–	–	f2S	–	–	–
46. *Maytenus senegalensis*	r2S	–	r2S	–	–	–	–
47. *Mimosa hamata*	–	r2S	–	–	–	–	–
48. *Mucuna prurita*	–	–	–	–	–	–	r2S

	Species	Communities						
		1	2	3	4	5	6	7
49.	*Opuntia dillenii*	–	r1S	–	–	–	–	–
50.	*Salmalia malabarica*	–	–	–	–	f2S	–	–
51.	*Sterculia urens*	–	–	–	–	–	–	f2S
52.	*Terminalia tomentosa*	–	–	–	–	–	–	r2S
53.	*Tinospora cordifolia*	–	f2S	–	–	–	–	r1S
54.	*Vallaris solanacea*	–	–	r1S	–	f1S	–	f2S
55.	*Vitex negundo*	r2P	–	f3P	–	–	–	r2S
56.	*Woodfordia fruticosa*	–	–	–	–	–	–	a4C
57.	*Wrightia tinctoria*	–	–	c2S	–	–	–	–
58.	*W. tomentosa*	–	–	–	r1S	–	–	–
59.	*Zizyphus nummularia*	–	f4C	–	–	–	–	–
60.	*Z. xylopyra*	–	–	–	–	f2P	r1S	f2S

Observations

Kumbhalgarh is one of the highest hills of Aravalli mountain. The vegetation of the area shows striking differences from that of surrounding plains of western Rajasthan. The vegetation is typical of humid regions like Mount Abu. The general characters of vegetation is tropophyllous.

The vegetation of hills shows distinct zonation and is dominated by perennial species such as *Jatropha curcas*, *Adhatoda vasica* and *Annona squamosa* at the base ; *Euphorbia nivulia*, *Woodfordia fruticosa* and *Hamiltonia suaveolens* in the middle zone and *Anogeissus latifolia*, *Sterculia urens* and *Boswellia serrata* at the top. The ephemeral species however do not show any such zonation.

The vegetation of this area resembles very closely with that of the other investigated hilly areas of Rajasthan in having Leguminosae, Gramineae, Compositae, Euphorbiaceae, Malvaceae, Acanthaceae and Labiatae as dominant families and *Cassia*, *Indigofera*, *Euphorbia*, *Ipomoea* as dominant genera. However, in the present investigated area there is a higher percentage of tree species, a luxuriant growth of woody and herbaceous climbers and twiners, rich Bryophytic and Pteridophytic flora, a comparative longer life of ephemeral plants and higher frequency of species of sub-Himalayan tract (Viz. *Cassia fistula*, *Woodfordia fruticosa*, *Mallotus philippensis*, *Diospyrus melanoxylon* etc.). These facts suggest that the vegetation of this area is more rich and approaches that of Mount Abu, the highest peak of Aravalli ranges.

Summary

1. The present investigation is a contribution to the plant ecology of Kumbhalgarh—Aravalli hills.

2. The general characters of vegetation, plant communities recognised in the area and the phytosociological characters of the perennial species are given.

3. It is concluded that the vegetation of this area is of dry deciduous type.

Acknowledgement

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VEGETATION IN RELATION TO CLIMATE AND SOIL— A CORRELATION OF FACTORS FOR NORTH KANARA FORESTS

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Correlations between the edaphic factors and vegetation have been reported by many workers (Troup, 1921 ; Seth and Yadav, 1960). Although by some edaphic factors are considered more responsible for the occurrence of a particular type of vegetation at a particular site (Moore, 1959), yet, in general it is favoured to recognise the sum total of the environment in relation to all other factors as most important ecologically (Cain, 1944, Billings, 1952). A preliminary effort on these lines is made here by the author to evaluate vegetation climate-soil relationship for the district of North Kanara, a high rainfall area situated along the western ghats of India between 13°55′–15°31′ N and 74°9′–75°4′ E, studies on which have been carried out during 1958–60.

TABLE I

Rainfall, Vegetation and Soil (North Kanara)

	Place	Rainfall in cm	Vegetation	Soil
1.	Mundgod	106	Scrub forest, *Butea* type ; *Gymnosporia-Ixora* type.	Hard, shallow, greyish.
2.	Haliyal	107	Scrub forests on north merging with Dharwar. *Gymnosporia–Ixora* type. Teak at places with *Pterocarpus marsupium.*	Black soil.
3.	Supa	220	Scrub-deciduous forests (Teak/Bomboo types)	Black, alluvial.
4.	Sirsi	235·5	Semi-evergreen/evergreen, moist deciduous types.	Black or red; laterite exposed at places.
5.	Yellapur			
6.	Siddapur	270	Laterite scrub, evergreen forests	Laterite exposed hillock; deep, red, soils from granite/gneiss.
7.	Karwar	296	Coastal scrub ; semi-evergreen-wet evergreen types.	Coastal sand ; deep ferrugenous clay.
8.	Ankola	309		
9.	Honavar	332		
10.	Kumta	346		
11.	Bhatkal	362		
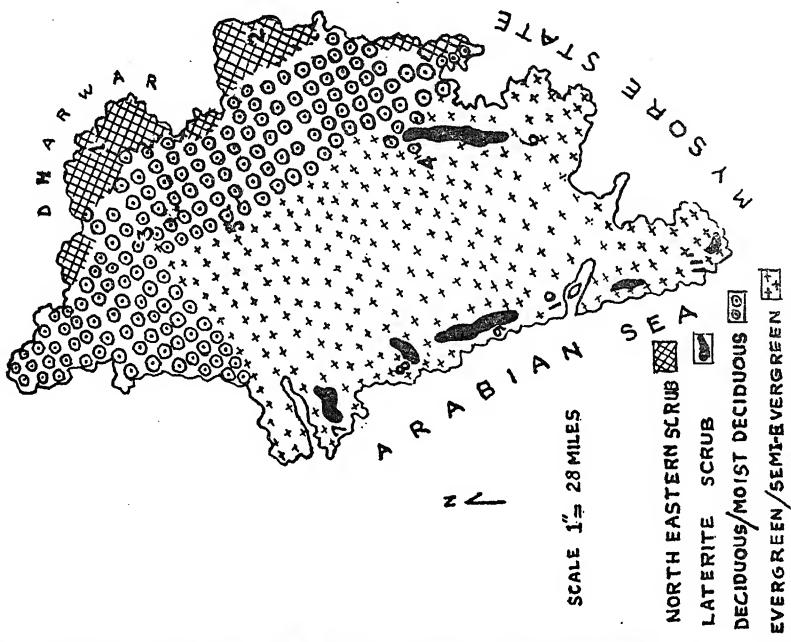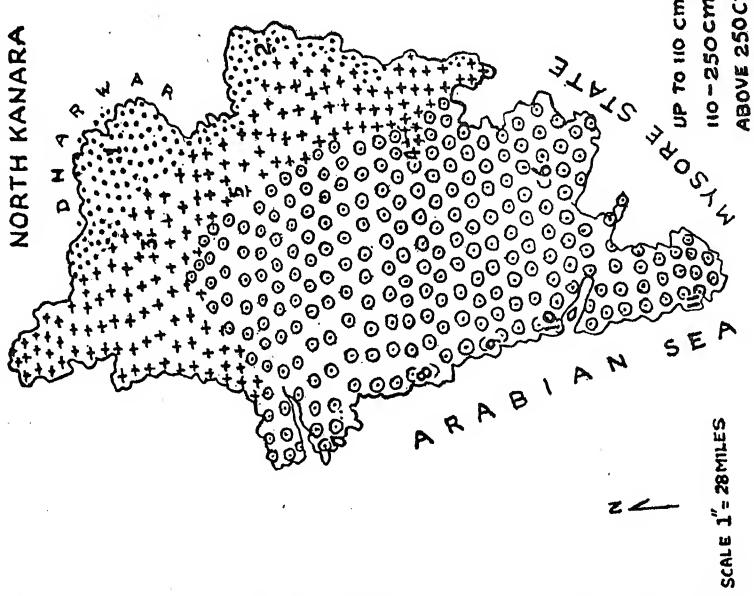
Fig. 1. The distribution of rainfall (map a) and vegetation types (map b) in North Kanara. Localities 1—11 in the maps are : 1. Mundgod, 2. Haliyal, 3. Supa, 4. Sirsi, 5. Yellapur, 6. Siddapur, 7. Karwar, 8. Ankola, 9. Honavar, 10. Kumta, 11. Bhatkal. For soil features, *see* Table 1.

North Kanara is mostly·hilly and ·a broken and irregular range of central hills divides it into three parts ; the central uplands with an area of 3000 sq. miles, and the two lowlands on west and northeast covering about 1800 sq. miles. The lowlands on the north support a scrubby type of vegetation where *Ixora arborea* and *Gymnosporia montana* (Arora, 1961) predominate. The climax attained here is a Teak and/or Bamboo mixed forest with associates like *Adina cordifolia, Emblica officinalis, Grewia tiliaefolia* and *Terminalia tomentosa.* The uplands along the slopes that merge with the lowlands support moist deciduous vegetation in initial stages which changes over to semi-evergreen and evergreen types with rise in altitude and increase of precipitation. Such areas are chiefly located along the west (ghat forests of the coastal region) and along the central and southern parts of the up-lands where rainfall often exceeds 300 cm. per annum. It is here that the tropical evergreen forests are met with (Arora, 1963) with components like *Artocarpus hirsuta, Diospyros microphylla, Garcinia* spp., *Hopea wightiana, Holigarna grahamii, Knema atten-nata, Litsaea* spp. *Cinnamomum zeylanicum,* and *Polyalthia fragrans.* The vegetation in relation to climate for different localities of North Kanara is given in Table I. Soil features are also indicated. Fig. 1 illustrates the same.

Soil types

Three types of soils are met with in the district apart from the coastal sand. These are,

1. The Red soils,
2. The Black soils, and
3. The laterite soils,

all being disintegration products of either granite, gneiss or laterite. The red soils cover a large portion of the uplands. They vary greatly in fertility and are in general deficient in nitrogen, phosphorus and lime. They are sandy loam in texture and have a low base exchange capacity. The laterite soils both *in situ* and sedimentary formation are comparatively poor in nitrogen, phosphorus, potassium and calcium. They are comparatively infertile and their hard, vesicular structure under the prevailing environmental conditions makes them unfavourable for the growth of tree species. On the red soils, two forest types have been studied. Under *Xylia* mixed forests the soils are observed to have a pH of 6·2, nitrate nitro-gen 64 lbs. per acre, phosphorus 150 lbs. per acre, replaceable calcium 1400 parts per million and potassium 260 lbs. per acre. Where the vegetation is a tropical evergreen forests the red soils possess pH between 5·8–6·2, nitrogen 32 lbs. per acre, phophorus 75 lbs. per acre, replaceable calcium 1000 parts per million, potassium 400 lbs. per acre (based on analysis of 8 surface soil samples, 4 in each forest type, done by La Motte Kit ; also *see* for different depths, appendix).

The black soils prevail in the lowlands of the district and support moist deciduous and/or scrubby vegetation depending on whether the soil is moderately deep or shallow. The open land supports a scrubby vegetation of *Carissa congesta, Flacourtia indica, Fluggea* sp. *Ixora arborea, Lantana camara, Zizyphus oenoplia, Gymnosporia montana* with malformed stunted tree growth of *Bauhinia racemosa, Buchanania lanzan, Butea* sp. *Diospyros melanoxylon* and *Lagerstroemia parviflora.* The deep black soil is very fertile and in the forest areas supports a Teak mixed and/or bamboo mixed type of vegetation with associates like *Adina cordifolia, Emblica officinalis, Dillenia pentagyna,* bamboo spp., *Lagerstroemia lanceolata, Grewia tilaefolia* and *Terminalia* spp. The soil data for this type are for soils collected at Dandeli where a bamboo mixed

growth prevailed. The soils are found to have a pH of 6 4–6·8, nitrogen 12 lbs. per acre, phosphorus 150 lbs. per .acre, replaceable calcium 2100–2800 parts per million and potassium 350 lbs. per acre (based on analysis of 6 surface soil samples by La Motte Kit) thus differing from the red soils.

The black and red soils under different vegetation can be correlated as follows (analytical data for 14 soil profiles given in appendix).

1. All the soils are acidic, the red being more acidic than the black soils. However the difference between the pH values of soils under *Xylia* mixed and moist deciduous types decreases considerably.

2. Nitrate nitrogen is comparatively higher in red soils developed under evergreen and semi-evergreen forests than in black soils developed under moist deciduous forest.

3. Calcium content is highest in the black soils which support moist deciduous forests, less so in the semi-evergreen and lowest in the evergreen type.

4. No significant difference in potash content is exhibited.

Some soil samples collected by the author were analysed by Singh (1961). These data for four soil samples under different vegetation types (for exchangeable calcium, magnesium and potassium in m.e. 100 gm. soil) are presented below :

Vegetation type	Calcium	Magnesium (in m.e. 100 gm. soil)	Potassium
Evergreen	15·18	6·31	5·43
Semi-evergreen	20·57	7·18	1·507
Moist deciduous	25·64	6·79	1·15
Laterite scrub	7·69	2·12	1·91

These data also point out the same conclusions for the exchangeable calcium. As for magnesium, no definite correlation with vegetation type is pointed out while for potassium a corresponding decrease is noted from evergreen to moist deciduous types. Laterite soils are seen to be poor in calcium and magnesium in comparison to potassium.

Discussion

The role of geology and soil in governing the distribution of forest types has been stressed by Chengappa (1934, 1944) according to whom the evergreen forests in Andaman occur on noncalcareous micaceous sandstone while the semi-evergreen *Dipterocarp* type is found mainly on conglomerate and hard metamorphic substratum. A similar conclusion for forest type and soil type has been worked out for Assam where based on pH and soil moisture requirement two distinct types of vegetation *viz*. Hollock (*Terminalia myriocarpa*) and Hollong (*Dipterocarpus macrocarpus*) communities are reported to occur (*see* Seth and Yadav, 1960). For the humid tropics of western ghats Aiyer (1932), Kadambi (1941), have pointed out to the occurrence of distinct types of forest communities (*Elaeocarpus–Vateria/ Palaquium* mixed, *Calophyllum–Mesua* mixed etc.) in Palghat and Mysore state, based on moisture requirement and drainage conditions.

APPENDIX

1. DATA FOR SOIL PROFILES UNDER EVERGREEN TYPE

Vegetation	Depth	pH	Nitrate Nitrogen, lbs. per acre	Average Phosphorus (lbs. per acre)	Replaceable Calcium (parts per million)	Potash (lbs. per acre)
Diospyros microphylla, Xylia xylocarpa, Myristica attenuata, Strychnos nux-vomica Cinnamomum zeylanicum, Holigarna arnottiana ; Leea indica, Piper, Pothos, Psychotria, Grewia microcos. Regeneration of *Cinnamomum, Diospyros, Myristica, Nothopegia* and others.	0''	6·2	32	150	1000	300
	6''	5·4	32	75	750	300
	12''	5·4	32	75	500	300
	18''	5·4	32	75	500	180
Cinnamomum zeylanicum, Olea dioica, Myristica attenuata, Terminalia tomentosa, Diospyros microphylla, Tabernaemontana heyneana, Ixora brachiata, Memecylon talbotianum, Ixora nigricans, Psychotria truncata, Leea indica, Piper, Pothos, Gnetum. Regenration of *Diospyros, Myristica* and *Cinnamomum.*	0''	6·2	32	50	1400	400
	2''	5·8	8	50	1000	220
	6''	5·8	16	25	700	180
	12''	5·8	3	25	700	140
	18''	5·2	3	25	700	140
	24''	5·2	3	25	700	100
Cinnamomum zeylanicum, Diospyros microphylla, Olea dioica, Holigarna arnottiana, Actinodaphne, Cedrella, Flacourtia montana, Caryota urens, Aporosa lindlevana, Myristica attenuata, Piper, Pothos, Psychotria, Leea, Memecylon. Regeneration of *Holigarna, Nothopegia, Cinnamomum, Myristica* and *Diospyros.*	0''	6·0	48	75	350	400
	2''	5·8	16	75	350	180
	6''	5·2	24	75	350	160
	12''	5·4	24	75	350	120
	24''	5·4	24	75	350	120
	30''	5·4	24	75	150	100
Heynea trijuga, Vitex altissima, Saraca indica, Polyalthia fragrans, Holigarna arnottiana, Actinodaphne, Cedrella toona, Ixora brachiata, Murraya koenigii, Chelletia chelonoides, Glycosmis pentaphylla, Carvia callosa, Olea saplings. Regenration of *Cinnamomum, Polyalthia, Allophyllus serratus.*	0''	6·0	32	150	2100	300
	2''	5·8	32	150	2100	300
	6''	5·6	32	100	1000	220
	12''	5·6	24	150	1400	220
	18''	5·6	16	200	1000	220
	24''	5·0	8	100	350	220

Vegetation	Depth	pH	Nitrate Nitrogen, lbs. per acre	Average Phosphorus (lbs. per acre)	Replaceable Calcuium (parts per million)	Photash (lbs. per acre)
Xylia xylocarpa, Cinnamomum zeylanicum, Tabernaemontana heyneana, Terminalia paniculata, Atalantia sp.; *Glycosmis pentaphylla, Acacia concinna, Allophyllus cobbe*; Regeneration of *Xylia, Cinnamomum* and *Tabernaemontana.*	0″	6·2	64	200	2800	220
	2″	6·2	48	200	1400	220
	6″	6·0	32	200	1000	220
	12″	6·0	24	150	700	140
	24″	6·0	24	150	150	140
	30″	6·0-5·8	24	200	150	160
ditto Regeneration of evergreen species prominent on the field layer.	0″	6·0	64	150	1400	400
	2″	5·6	48-64	150	1000	300
	6″	5·4	32	150	700	180
	12″	5·4	24	150	700	160-180
	18″	5·6	24	200	350	140
	24″	5·4	24	200	150	140
Xylia—Tabernaemontana type with bamboo undergrowth.	0″	6·4	64	200	1400	260
	6″	6·2	32	150	1000	260
	12″	5·8	24	150	700	160
	24″	5·8	8	150	350-700	120
ditto With evergreen undergrowth of *Cinnamomun, Litsaea, Actinodaphnes*	0″	5·8	64	150	1400	400
	2″	5·4	64	100	1000	220
	6″	5·6	48	200	1000	600
	12″	5·6	8	100	1400	160
	24″	5·4	3	100	1400	160

Vegetation	Depth	pH	Nitrate Nitrogen, (lbs. per acre)	Average Phosphorus (lbs. per acre)	Replaceable Calcium (parts per million)	Photash (lbs. per acre)
Terminalia tomentosa, Bambusa bambos, Dendrocalamus strictus, Xylia xylocarpa; Bamboo clumps prominent. Regeneration of *Xylia*, seedlings of *Mallotus phillipensis, Grewia tiliaefolia* and *Lagerstroemia.*	0″	6·6	12	150	3500	380
	2″	6·4	3	150	1400	200
	6″	6·4	3	200	1400	200
	12″	6·2	3	150	1400	200
	15″	6·2	3	100	1400	160
	24″	6·0	3	200	1400	170
Bamboo clumps; with above vegetation; undergrowth of *Zizyphus, Calycopteris, Flemingia, Desmodium.* Thick cover, with *Xylia* regeneration.	0″	6·8	16	200	3500	350
	2″	6·2	8	100	2800	280
	4″	5·8	3	100	1400	220
	6″	5·4	3	100	1400	180
	12″	5·4	3	200	1400	220
	18″	5·6	3	150	1000	200
	24″	5·6	3	150	1000	180
Bamboo, Teak, *Terminalia Albizzia stipulata, Dalbergia paniculata, Xylia, Dillenia, Grewia tiliaefolia*; with poor regeneration of *Xylia.*	0″	6·8	32	200	2800	400
	2″	6·4	12	100	1400	300
	4″	6·0	8	75	1400	300
	9″	5·6	3	75	1000	400
	12″	5·6	3	75	1000	120
	24″	5·6	3	50	1000	160
Teak and Bamboo; *Lagerstroemia lanceolata, Terminalia tomentosa, Dalbergia latifolia, Diospyros montana* and *Spondias.* Regeneration of *Xylia, Dalbergia, Grewia.* Dense Bamboo undergrowth.	0″	6·8	8	150	2100	300
	2″	6·2	3	75	1400	160
	4″	5·6	8	100	1000	160
	6″	5·6	3	100	1000	120
	12″	5·6	3	100	1000	120
	18″	5·4	3	100	1000	140
	24″	5·4	3	150	1000	120
Bamboo clumps; *Dalbergia latifolia, Stephgyne parvifolia, Dillenia pentagyna, Xylia xylocarpa.* Regeneration of *Xylia, Dalbergia,* Bamboo.	0″	6·2–6·4	16	200	2100	220
	2″	6·4	16	200	2100	220
	6″	6·0	8	300	1000	220
	12″	5·8	13	200	1400	220
	24″	5·5	13	200	1400	180
Bamboo clumps; *Eugenia* spp.; *Xylia xylocarpa, Terminalia paniculata, Tabernaemontana heyneana.* Regeneration of *Xylia xylocarpa, Dalbergia latifolia, Tabernaemontana heyneana*; seedling of *Eugenia* also present.	0″	6·0	16	200	1400	300
	2″	5·8	24	150	1400	300
	6″	5·6	32	150	1400	300
	12″	5·8	3	150	2100	220
	22″	5·6	3	100	2100	220
	30″	5·8	3	100	1400	160
	36″	5·8	3	100	1400	160

Estimations based on La Motte Kit.

The correlation of soil features with climate and the prevailing vegetation as presented above for N. Kanara points out that :

1. The black soil type is associated with a climax of moist deciduous type and prevails in low-moderate rainfall areas of the district (Table I, localities 1-3).

2. The red soil type is associated with a climax of rain forest type and prevails in high rainfall areas of the district (Table I, localities 4-11).

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MALFORMATIONS IN MANGO BLOSSOMS

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Introduction

The malformations in mango blossoms are of common occurrence in the local mango orchards. Their first record was made by Maries in 1891 in Bihar and later their occurrence was reported from the Bombay Presidency (Burns, 1910). Singh and Chakravarti (1935) described the symptoms of the abnormal inflorescences in mango and the extent of damage caused by the same in Varanasi, while Sen (1947) reported his observations on the malformations in mango occurring in Sabour (Bihar). From West Pakistan it has been reported by Khan and Khan (1960). Singh *et al* (1961) have described the symptoms, extent, intensity and cause of these malformations in mango blossoms from Saharanpur. Tripathi (1954) suggests the use of the term 'mango malformation' for the bunchy top and floral malformations both in order to avoid confusion.

During the course of the survey of 'black-tip' disease of mango fruit, in the local orchards, malformed blossoms were observed by the author in a number of trees. In the most susceptible varieties like Dasehri, Khajri and Husn-e-ara the percentage of malformation appeared to be very high. The flowers of the malformed inflorescences do not develop fruits. There is thus a substantial loss to the crop due to this disease. It was further observed that there was more than one type of malformation occurring on the various varieties growing in Lucknow orchards (Sharma, 1953). Apart from supplementing some of the observations made by other workers, the author, in this paper, has reported his observations based on the survey work carried out for 4 years in the neighbourhood of Lucknow and has also given illustrations of the different forms of malformed blossoms in the various varieties of mango grown in this region. The work was, however, initiated with a view to find out the factor or factors responsible for the disease.

Survey

Intensive survey was carried out of eight orchards in the vicinity of Lucknow. In each season the survey work was started in the first week of February and was continued till the end of July. The survey data of each year of observation were maintained in the form of survey maps for each orchard.

The diseased inflorescences start appearing on the susceptible varieties right from the initial stages of the flowering of the affected tree and usually persist (with slow development) even after the fruiting season of the orchard is over, falling off gradually as they dry up by the end of June. It was observed that there is practically no distinction between the normal and malformed inflorescences in their early stages of development. The first visible difference in their morphology is noted only when the flower, bearing lateral axes, develop and grow in size. In later stages of flowering, however, the malformed branches can easily be recognised by their persistent fresh green colour, closed and compact shape and the absence of fruiting as against the normal reproductive branches.

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So far as the incidence of the disease is concerned, it occurs in all parts of the orchards and is not localised in any particular section. The phenomenon recurs year after year in the same tree or a group of trees, although the percentage of malformed blossoms varies widely in different years. The behaviour of the individual trees in various years of observations has been found to be variable. It may be that they are heavily malformed regularly or the recurrence may be irregular, in some years low and in others considerably high or, a normally healthy tree may exhibit heavy malformation suddenly in any one year or, sometimes the percentage of malformation in a group of trees may be constant in at least three successive years of its recurrence. In some cases the incidence of the disease gradually increases in each subsequent year of attack and a heavily malformed tree, after becoming entirely free of the malformations in one season, may again be considerably malformed in subsequent seasons. On the other hand, trees getting diseased for many years may later become absolutely healthy. There are trees which flower irregularly, in some years they remain only vegetative. Some such trees have been found to repeat the phenomenon whenever flowering occurred in them. The trees of the same variety growing in the neighbourhood of a heavily malformed tree may bear absolutely unaffected blossoms.

The extent of damage, in the various varieties of mango commonly grown in this region, has been worked out as follows :

(a) Below 5% .. Ab-e-Hayat, Benazir, Desehri (Tambooria), Fajri, Gola, Safeda (Lucknow) and Tukhmi (seed grown).

(b) Upto 15% .. Amin, Khajri, Krishna-Bhog, Langra, Mohanbhog, Safeda (Malihabad) and Sinduria.

(c) Upto 30% .. Bombai, Desehri, Dil-Pasand and Husn-e-ara.

There may, of course, be trees which sometimes bear even 100% malformed blossoms in one season. The average percentage of malformed blossoms in 2-4 year old Desehri plants of Lucknow nurseries was 15–20%, which in some cases reached to 95%. The flower bearing shoot of these young plants is usually pruned to save them from early fruiting. The second flush of flowers appearing after the pruning was again malformed although with less virulence and lower percentage.

Different forms of malformations

The various forms of malformations, collected from the common mango varieties of this region, have been grouped into two main heads—the 'Compact' type including three forms and the 'Spreading' or the 'Loose' type including two forms.

(A) *The 'Compact' type* :

(i) A most common type of abnormality occurring on the Desehri and Khajri varieties of mango is where the flower buds remain closely massed together at the top of the axillary branches with foliaceous green bracts (Text Fig. 1 ; Plate, Fig. 2). Malformations of the Khajri variety often bear large open flowers but they do not set fruits.

(ii) In the axil of a few leaves of almost all the susceptible varieties, are often seen small malformed branches having short needle like leaves. These 'needles' dry up early, turn pale brown and become hard. This may either be entirely vegetative (Text Fig. 2) or a group of flower buds or flowers representing

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an undeveloped telescoped inflorescence axis may be present in the axil of these 'needles' (Plate, Fig. 4).

(iii) Another form of giganticism, occurring in Desehri variety, is a big rounded ball-like malformation, green in colour, and possessing a large number of small green bracts which include a number of flower buds among them. These are produced singly on one branch and generally remain fresh green even upto July and have also been seen in dried condition along with the blossoms of the following mango season (Plate Fig. 3).
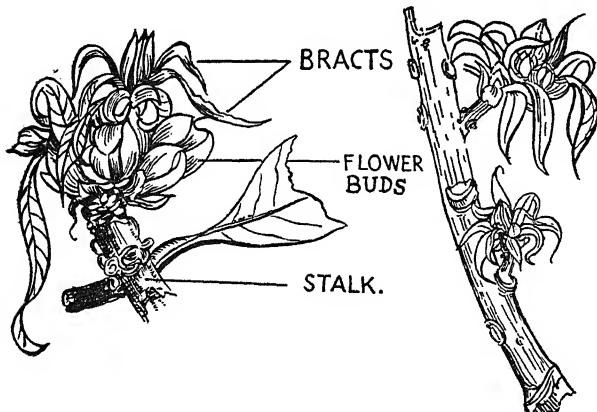
Text Figure 1. Malformed blossom of the 'compact'—A (i) type.

Text Figure 2. A malformed vegetative branch—A (ii) without any flower or flower buds.

(B) The 'Spreading' type :

(i) The central axis in this type, fouud only in the Gola variety, is more thick, short and striated longitudinally than in the healthy inflorescence. The lateral axes remain bare for some distance towards the base and all the flowers are aggregated apically, most of which remain in bud condition and those, which open, dry up soon without setting a fruit. There are no bracts in such inflorescences (Text Fig. 3).

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FLOWER
BUDS

PEDICELS

MAIN STALK
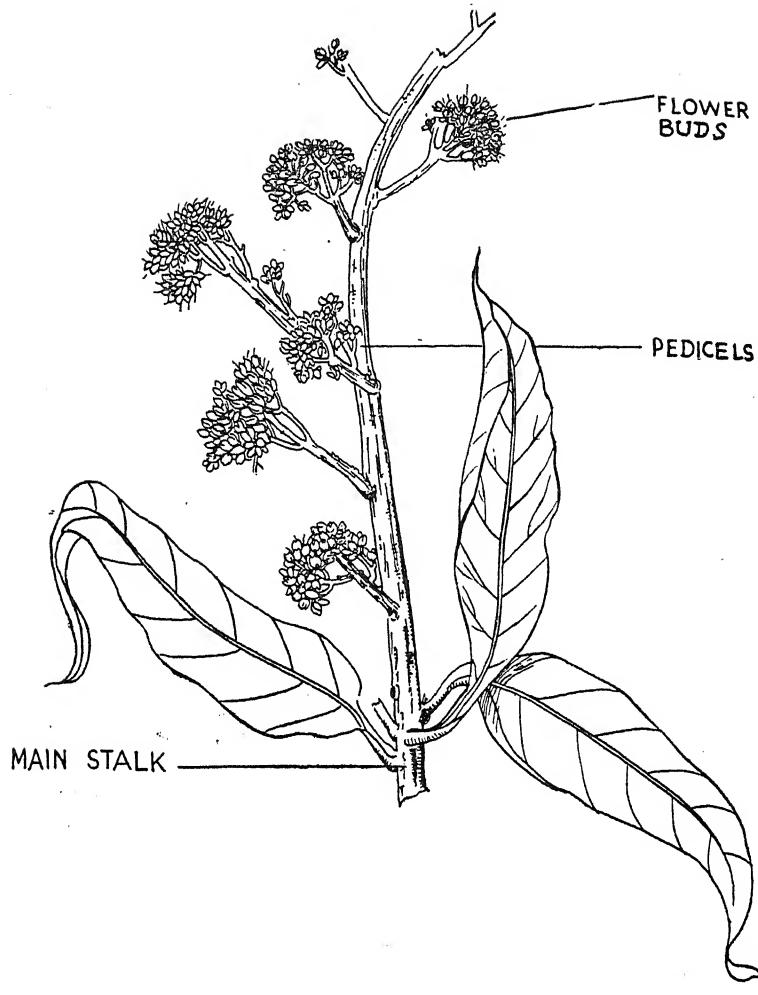
Text Figure 3. Malformed blossom of the 'Spreading'—B (*i*) type—found in the Gola variety only.

(*ii*) Another form of this type has been collected only from the Husn-e-ara variety in which the healthy and malformed inflorescences are similar in having pink, slender and glaucous floral axes which droop downwards. The flowers of the malformed blossoms never open out and the entire inflorescence remains fresh much after the fruiting has finished on these trees (Text Fig. 4).

Causation

The malformations, in general, are caused by fungi, bacteria, virus, nutritional disorders and insects. The experiments performed in this case were initiated primarily to include all these aspects, and some of these observations are presented below.

In order to see if the disease was associated with a fungal or bacterial organism, a number of direct inoculations and moist chamber cultures were made from the central and lateral axes of the inflorescences as well as the flower buds. A large number of direct inoculations were taken on standard synthetic, potato dextrose and oat meal agar media from the representative areas of the malformed inflorescences and of the corresponding regions from the healthy blossoms belonging to Khajri, Dasehri and Husn-e-ara varieties of mango after surface sterilisation in the usual manner. No organism, either fungus or bacteria, was isolated from any of these inoculations.

MAIN STALK
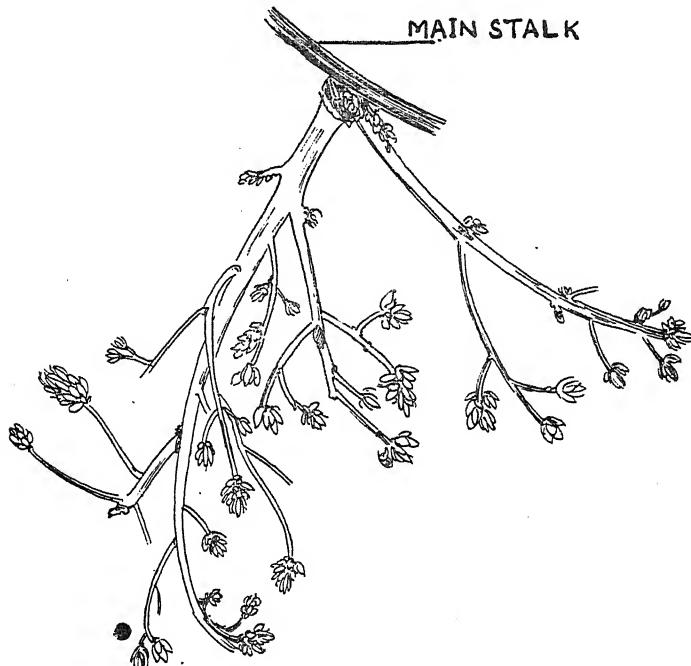
Text Figure 4. Malformed blossom of the 'Spreading'— B (ii) type—occurring in Husn-e-ara variety.

An attempt was also made to reproduce the disease by treating the healthy inflorescences of the Dasehri variety, in their young stages of development, with the extract of the malformed blossoms. For this purpose the extract of a few malformations from the Desehri variety was prepared and made sterile by passing it through the Seitz filter. The experiments were conducted at an early stage of the flowering on a healthy tree by (a) spraying the extract twice every day for one week on 65 unwounded and 25 wounded blossoms, (b) dipping the entire inflorescence (30 in number) in the extract for 5 minutes once every day for three days, (c) injecting the extract into the blossoms (35 in number) by means of a hypodermic syringe at three points : (i) at the point where the inflorescence stalk is attached to the stem, (ii) at a little distance above this point, and (iii) on the central axis.

The disease could not be reproduced by any of these methods which indicates that there is probably no such deleterious constituent present in the malformed blossoms which could be transmitted mechanically.

To ascertain if nutritional deficiency is the cause, experiments were carried out in which a number of 'branch injections' (Roach, 1934) were made from the lateral branches towards the base of young malformed blossoms of the commonly susceptible Desehri, Khajri and Husn-e-ara varieties. The injections were given with (a) standard Knop's solution [Ca (No$_3$)$_2$·4H$_2$O— 0·8 gms., KNO$_3$, KH$_2$PO$_4$ and MgSO$_4$. 7H$_2$O each 0·2 gms. dissolved in 1000 c.c. of distilled water. FePO$_4$ (trace) was eliminated from this] to 50 blossoms and, (b) Knop's solution of the above constitution plus traces of (i) boron (as borax), (ii) zinc (as zinc sulphate), (iii) iron (as ferric phosphate) separately to 20 blossoms in each case.

The solutions were periodically replenished whenever their level fell below a certain minimum. These experiments also yielded negative results.

In order to see if any insect was associated with this phenomenon, malformed blossoms from the Desehri, Husn-e-ara and Khajri varieties were collected along with the healthy inflorescences of approximately the same age, preferably from the same branch. The central and the lateral axes from both these sets were microtomed (14–16μ thick) and suitably stained. As against the nearly circular outline of these axes in the case of the healthy inflorescences, those of the malformed inflorescences are distinguished by several acute ridges and deep narrow ingrooves (Plate, Fig. 5). The epidermal and the hypodermal cells of these acute ridges become enlarged nearly by 1$\frac{1}{2}$ to 2 times of their dimensions in the healthy axes. They measure 18–29μ × 13–16μ and 16–45μ × 13–23μ respectively. Similarly the cortical cells inside the ridges of the malformed axes get radially elongated, nearly 2 times, their average size becoming : 90–112μ × 31–48μ. Otherwise the tissues are normal and without lacunae. The presence of any kind of insect and its associated developmental stages was not found in any of the tissues of the diseased axes.

Discussion

Malformation of the mango blossoms causes considerable damage to the crop in U. P. The occurrence of the disease has been reported from Bombay, Punjab, Bihar, Varanasi, Saharanpur and also West Pakistan. Singh and Chakravarti (1935) have described the general symptoms of these abnormal inflorescences occurring in Varanasi, and have divided them broadly in two groups : 'compact' and 'semi-compact'. No further distinctions have, however, been recognised from the various mango varieties, as are dealt with in this paper. Singh *et al* (1961) have distinguished vegetative and floral malformations in Saharanpur ; the former occurring usually in plants of the nursery and also in older plants of the grafted or seedling types, while the latter are further divided into 'compact' and 'loose' types both having shoots either flower bearing or without flowers, having only scaly leaves. Sen (1947) has made some observations regarding this giganticism in mango blossoms at Sabour (Bihar). He observed that the local varieties and those introduced from the neighbouring U. P. districts do not generally show the malformations under Bihar conditions, while some varieties which are free from the disease in Bombay and Madras are very seriously affected when cultivated in Bihar.

During the course of survey it was observed that the malformed blossom, in general, presents a hypertrophied structure which in most cases is accompanied by an under-development of flowers which usually do not grow beyond the bud stage except in a few cases where, if the flowers open, they assume an unusual large size without any fruit setting. Similar is the case in the development of the flowers from the curd of broccoli (Masters, 1849 ; Worsdell, 1916 and Dark, 1938).

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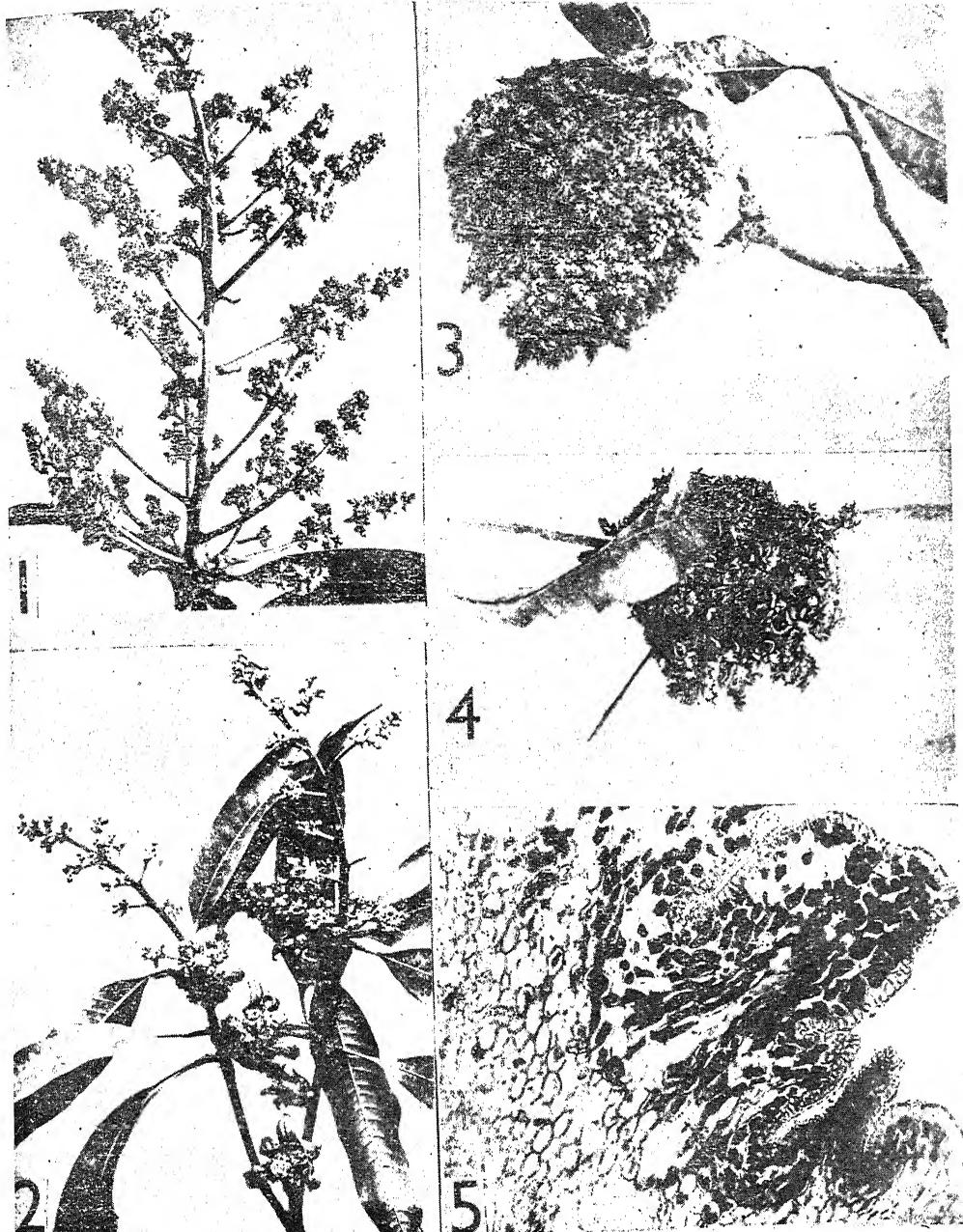
EXPLANATION OF PLATE

Fig. 1. A normal healthy inflorescence of mango.. X ca. 2/5.
Fig. 2. A mango twig with malformed blossoms towards the base while healthy infloreseences
         are continued up.
Fig. 3. Malformed blossom of the A (*iii*) type.
Fig. 4. Malformed blossom of the A (*ii*) type developing at the forking point of the branches.
Fig. 5. Microphotograph to show the acute ridges and deep ingrooves of the malformed axes.
         X92.

An attempt to investigate into the cause of the disease has shown that no fungal or bacterial pathogen is associated with the production of the disease. The disease can not be reproduced by treating the healthy inflorescences variously at their initial stages of development with the extract of the malformed blossoms of the same variety (Sharma, 1953). This indicates that the disease cannot be mechanically transmitted. Similar results have been reported by Burns and Prayag (1920) and Singh et al (1961). Lehman (1938) describes the leaf malformations in tobacco plants near Releigh, North Carolina in which, too, the attempts to transfer the malady by mechanical inoculations gave negative results. Benjamin Koehler (1939) has described the 'crazy top of corn' in which the tassell is replaced by a large bunchy vegetative growth. The cause of this abnormality is unknown but is supposed to obviously operate before the differentiation into the floral organs takes place. Similar may be the case with the malformations of the mango blossoms.

Narsimhan (1954) has described a witches' broom like malformation in the panicle of mango from Poona and reports it to be incited by a mite of the genus *Eriophyes*. All the stages of the developing mite have been reported in the lacunae produced within the host tissue. The cortex and the stele of the affected inflorescences are considerably transformed accompanied by the development of the hyperplastic cells. Le Froy (1909) in his book "Indian Insect Life" has described the occurrence of some species of *Idiocerus* which attack and feed on the sap of young growing shoots of mango. Consequently they prevent the shoot development and destroy the flowers completely. The cause of these malformations being entomological is not completely ruled out by Singh et al (1961). They have correlated certain plant parastic mites with the production of these malformations.

Histological studies of the malformed blossoms and inflorescence axes carried out here have not revealed any kind of insect or its associated developmental stages. Neither the tissues of the diseased branches show any development of lacunae in them. Only the epidermal and the cortical cells of the acute ridges in the affected inflorescence axes become greatly hypertrophied. The stelar and the pith regions remain unaffected. Assuming that the "witches' broom" of mango, as shown by Narsimhan (1954), is due to the mite *Eriophyes*, it is clear from the author's results that the type of malformations studied here are due to causes other than the insect. In case, however, further investigations prove the malformation to be of virus origin, the insect vectors may play an important part.

The virus origin of the disease may also explain the intermixture of healthy and malformed inflorescences in one and the same branch of the affected tree, variations in the intensity and the recurrence of the disease year after year and also the occurrence of a healthy branch on the top of the malformed blossom, because such phenomena, in the virus infected plants, are not unknown (Smith, 1937; Willison, 1944 and 1945; Posnette, 1947 and Gilmer et al, 1952). Sattar (1946) attributes this disease to be virus in origin or due to physiological disorder. Khan and Khan (1960) proved that there is no relation of the disease with cultural practices like pruning, manuring or ringing.

Summary

The paper gives an illustrated account of 5 different forms of malformation in mango blossoms on the various varieties grown in the vicinity of Lucknow. A record of the incidence of disease based on intensive survey work has also been

given. It has been experimentally shown that the disease is non-pathogenic and also does not seem to be due to nutrition deficiency. It can not be transmitted mechanically and no insects of any kind have been found associated with the diseased tissues.

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FOLIAR ANALYSIS OF SOME IMPORTANT SPECIES OF HUMID TROPICS†

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Chemical analysis of leaves gives very interesting relationship regarding the mineral requirements and this has been used to asses soil conditions, fertilizer problems, hunger signs, etc. The amount of mineral contents in the foliage of a tree is generally considered to be an index of its nutritional requirements and the level of available minerals in the soil under existing conditions of climate. The differences in the foliar ash in the different species may be interpreted to be due to difference in the soil, and differences in the physiological characteristics of the species. In case of *banana*, it has been shown beyond doubt, that the ash content and the cations like Potassium, Calcium and Magnesium in the leaf are positively affected by corresponding available cations in the soil. Furthermore the rate of growth and minimum growth is also determined by the minerals in the soils, the deficiency of which also causes the corresponding decrease in the ash content of the leaves (Murray, 1960).

The importance of the present study may be apparent from the fact that the tree vegetation exercises a profound influence on the development of surface layers of the soil and seedling growth. By virtue of this capacity to absorb minerals from the lower layers of the soil and bringing them annually to the surface layers in the form of tree litter. In a nut shell, trees create conditions for or against their own production. The mineral contents of foliage of trees in the region of uniform climate, therefore, is an index of soil fertility and this throws light on the successful regeneration and succession of the plant communities in the forests and also it may help in the artificial raising of forests on a particular type of a soil.

Foliar analysis, as a guide in plant nutrition, crop yield, soil fertility and fertilizer treatment studies of soil, has been extensively employed specially in agricultural research in western countries and literature is not scarce in this aspect (Burkhart, 1941 ; Chapman, 1941 ; Davies, 1940 ; Gilbert and Smith, 1929 ; Hester, 1941 ; McCollam, 1944 ; Moser, 1941 and Scarseth, 1941). But its role cannot be overlooked in the modern practices of silviculture. Unfortunately very little is known in the field of forestry. There is no complete work on the mineral requirements of single Indian forest species though volumes have been written on their silviculture (Troup, 1921). So it was proposed to undertake detailed foliar analysis of the important species in different types of Tropical Rain Forests of western ghats and to study its correlation with the soil fertility as it may help in the understanding of plants, their physiology and environments.

Material and Methods

For the present study, the leaf samples of different species were collected from different types of vegetation and soil, so as to see if there exists any correlation between plant and soil. Care has been taken to collect mature, healthy leaves from the middle of crowns.

The leaves of the following species have been analysed by the method proposed by Piper (1944).

Deciduous species

Dendrocalamus strictus, Xylia xylocarpa, Anogeissus latifolia, Grewia tiliaefolia, Kydia calycina, Randia brandisii, Dalbergia lanceolata, Terminalia tomentosa, Carissa sp., Adina cordifolia, Careya arborea, Flacourtia indica, Emblica officinalis.

Evergreen species

Garcinia indica, Memecylon sp., Saraca indica, Leea indica, Vitex altissima, Neolitsea zeylanica, Vitex negundo, Actinodaphne hookerii, Macaranga peltata, Syzygium cuminii, Nothopegia colebrookiana, Palaquium ellipticum, Holigarna grahami, Polyalthea longifolia, Eugenia laeta, Canthium umbellatum, Holigarna arnottiana, Hopea wightiana, Ixora nigricans, Poeciloneuron indicum.

Findings

Chemical analysis of thirty-three species (13 deciduous and .20 evergreen) have been completed in the present work. The results obtained are tabulated in tables I and II. The species are arranged in the descending order/series based on the ash content in the leaves. The oven dried leaf samples were analysed for Ash, Silica, Calcium, Magnesium, and Phosphorus and the data is represented in percent of dry weight.

TABLE I

Showing the percentage of ash, silica, calcium, magnesium and phosphorus in deciduous species.

	Name of the plant	Ash	Si	Ca	Mg	P
1.	*Dendrocalamus strictus*	20·4	15·2	0·84	0·7	0·145
2.	*Xylia xylocarpa*	15·5	2·77	1·26	1·2	0·244
3.	*Anogeissus latifolia*	14·5	3·4	2·5	0·7	0·23
4.	*Grewia tiliaefolia*	12·4	2·88	1·06	0·95	0·28
5.	*Kydia calycina*	11·93	2·8	1·00	1·1	0·20
6.	*Randia brandisii*	11·00	1·2	2·9	0·98	0·22
7.	*Dalbergia lanceolata*	10·8	3·06	1·72	0·98	0·1108
8.	*Terminalia tomentosa*	8·94	0·94	1·72	0·8	0·24
9.	*Carissa sp.*	8·74	0·8	1·72	0·8	0·15
10.	*Adina cordifolia*	8·6	0·8	1·8	0·92	0·32
11.	*Careya arborea*	8·1	0·89	1·22	0·7	0·132
12.	*Flacourtia indica*	7·6	0·56	1·27	0·62	0·18
13.	*Emblica officinalis*	7·6	0·8	1·3	0·72	0·23

TABLE II

Showing percentage of ash, silica, calcium, magnesium and phosphorus in evergreen species

Name of the plant	Ash	Si	Ca	Mg	P
1. *Garcinia indica*	11·2	0·8	2·76	0·69	0·162
2. *Memecylon* sp.	10·43	2·00	1·92	1·63	0·157
3. *Saraca indica*	10·2	0·6	1·13	1·2	0·38
4. *Leea indica*	10·02	2·0	3·06	0·92	0·205
5. *Vitex altissima*	9·52	2·28	0·94	1·02	0·136
6. *Neolitsea zeylanica*	9·32	1·2	2·6	0·76	0·14
7. *Vitex negundo*	8·3	0·7	1·03	0·92	0·22
8. *Actinodaphne hookerii*	8·25	0·7	1·03	0·92	0·226
9. *Macaranga peltata*	8·24	0·3	1·68	0·6	0·22
10. *Syzygium cuminii*	8·2	2·3	2·2	1·02	0·18
11. *Nothopegia colebrookiana*	7·7	0·8	1·41	0·8	0·17
12. *Palaquium ellipticum*	7·5	0·7	1·00	0·8	0·15
13. *Holigarna grahami*	7·36	0·4	1·61	0·6	0·223
14. *Polyalthea longifolia*	7·3	0·9	1·09	0·98	0·22
15. *Eugenia laeta*	7·012	1·2	1·8	0·8	0·15
16. *Canthium umbellatum*	6·74	0·51	1·73	0·8	0·15
17. *Holigarna arnottiana*	6·68	0·77	1·05	0·9	0·18
18. *Hopea wightiana*	6·65	1·6	1·35	0·7	0·205
19. *Ixora nigricans*	6·6	0·89	1·2	0·6	0·125
20. *Poeciloneuron indicum*	6·5	0·5	0·92	0·6	0·22

Observations

The species analysed have been classified into four classes separately for ash, silica, calcium, and phosphorus to find out their range of distribution in deciduous and evergreen plants.

The four classes recognised for each element are shown in table III.

TABLE III

Showing the percentage of different minerals on which the four classes are based

Classes	Ash %	Ca %	Si %	Mg %	P %
I	5–8	0–1·0	0·6–0·9	0·6–0·9	0·1–0·15
II	8·1–12	1·1–2·0	0·91–1·3	0·91–1·2	0·151–0·20
III	12·1–16	2·1–3·0	1·31–1·7	1·21–1·5	0·21–0·25
IV	16·1–above	3·1–above	1·7–above	1·51–above	0·251–above

Based on the above four classes, the percentage of species belonging to each class was calculated for each element. The following Table IV shows percentage of species belonging to four classes.

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TABLE IV

Showing the percentage of species for the different minerals belonging to the four classes

		I	II	III	IV
Ash	Deciduous	15·4	53·9	23·1	7·7
	Evergreen	50·0	50·0	–	–
Si	Deciduous	46·2	7·7	23·1	23·1
	Evergreen	60·0	30·0	10·0	–
Ca	Deciduous	7·7	46·2	–	46·2
	Evergreen	0	40·0	25·0	35·0
Mg	Deciduous	46·2	46·2	7·7	0
	Evergreen	60·0	35·0	0	5·0
P	Deciduous	30·8	23·1	46·2	0
	Evergreen	15·0	35·0	40·0	10·0

Discussion

Based on the above data following conclusions can be drawn.

The ash content of evergreen species is generally low as compared to the deciduous species and is never more than 12 percent in the species studied. This may be due to the differences in the soil and in the physiological characteristics of the species. The Silica content is generally less in the evergreen species and is more in the deciduous species.

There is no apparent direct correlation between the calcium content of the leaves, but it appears that Calcium is usually low in evergreen species than in the deciduous species. The deciduous species belonging to class II *i.e., Xylia xylocarpa, Emblica officinalis,* are found in moist deciduous forests and sometimes even in semi-evergreen forests. This may be one of the reasons for having a lower percentage of calcium. Calcium content is almost always high as compared to the Magnesium.

Magnesium is low in evergreen species as compared to the deciduous species. The data for Calcium and Magnesium shows that there is a direct relationship of the mineral contents of leaves to the exchangeable mineral elements of the soil. The calcium and magnesium is low in the soils of evergreen forests than the deciduous forests. Probably operating therein is the moisture and temperature being different in the two type of forests (Ahuja, 1961 ; Ahuja and Singh, 1963).

Phosphorus seems to be high in the evergreen species than the deciduous species showing again the direct relationship with mineral contents of the soil as Beadle (1954) has reported that evergreen forests are usually found on soils rich in Phosphorus.

The present studies show that although the percentage of different elements and ash contents show certain basic trends in different species belonging to different forest types it is really difficult to demarcate certain hard and fast boundries which should separate different classes, groups of the species belonging to different forest type *viz.,* evergreen and deciduous. A detailed study of a single species growing in different type of environmental conditions may show the effect of the soil on the mineral contents of leaves and *vice-versa.*

Summary

Chemical analysis of leaves gives very interesting relationship regarding the mineral requirements and this has been used to asses soil conditions, fertilizer

problems, hunger signs etc. Keeping this in mind thirty-three species of deciduous and evergreen forests have been analysed for ash, calcium, magnesium, phosphorus and silica, by the method proposed by Piper (1944).

The ash content and silica is generally low in evergreen species than the deciduous species. It appears that calcium is usually low in evergreen species than in deciduous species. Calcium content is almost always high as compared to the magnesium. Phosphorus seems to be high in the evergreen species than the deciduous species.

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THE TRACHEATION IN THE LARVA OF *ACHOEA JANATA* LINNAEUS. (LEPIDOPTERA—NOCTUIDAE)

By

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Alt (1912), Peterson (1912) have made study on the tracheation of other insects and showed a great diversity in the distribution of subtracheae from the principle trunks. Snodgrass (1935) also gave a general account of tracheae in noctuid caterpillar. Similar account of these tracheae are also available in respect of larva of *Enarmonia pseudonectis* Meyr. (Teotia and Pathak, 1957). In the present studies the structure of the tracheation has been made in the mature larva of *Achoea janata* at Government. Agricultural College Kanpur.

Material and Method

The larva used in the study were dissected with very fine needles (No. 20) under the binocular microscope in normal saline water. The treacheae were examined and sketched with the help of camera lucida. The treacheal system of these larvae being dark brown gave considerable help in making the diagram. The technique adopted by Puri (1954) for sugarcane borers was also adopted but found to be unsatisfactory in these larvae.

The Tracheal System : The tracheal system of larva of *Achoea janata* communicates to the outside through the nine pairs of spiracles. The first pair of spiracles open near the posterior margin of prothoracic segment. The spiracles on the meso and methathoracic segments are absent.

The tracheal system of mature larva chiefly consists of a pair of tubular lateral longitudinal tracheal trunks (L. tra. tr.) one on each side of the body giving connections to spiracular tracheae from first thoracic spiracles to the last abdominal spiracles. The lateral longitudinal trunks give off three main branches in the neighbourhood of their junction *viz*. Dorsal trachea (D. tra.) going to the dorsal part of the body wall and dorsal blood vessel ; Ventral trachea (V. tra.) supplying to ventral musculature, nerve cord and legs and Visceral trachea (Vis. tra.) supplying branches to the walls of alimentary canal and fat bodies.

Tracheation of Head : The head and mouth parts are principally supplied by three large tracheal sub-trunks arising from prothoracic spiracles. These are dorsal (D) ventral (V) and median (M) tracheae. Each of these trancheae after running upward for a short distance bifurcates and finally ends in finer tracheoles which remify the various parts of the head.

Tracheation of thorax : Tracheation in the thorax is simple. The prothoracic spiracles (T. sp.) supply the tracheae not only to head but also meso and methathorax. The prothoracic leg is supplied by the Median trachea (M. tra.) which originates near the first abdominal spiracles. The main trunks are lateral longitudinal trunks which continue from the last abdominal spiracles to the prothoracic spiracles. The meso and metathoracic legs get connections of tracheae from the

lateral longitudinal trunks originating near the Ist abdominal spiracles. As stated above the lateral longitudinal tracheal trunks give dorsal, visceral and ventral tracheae in each segment. The ventral tracheae of two sides in each segment unite to form ventral commissure (V. com.).

Tracheation of Abdomen : In the abdomen there are eight spiracles and seven ventral commissures. The lateral longitudinal trunks extend posteriorly to the last pair of spiracles which is in the eighth abdominal segment. The principal branches are given from the lateral longitudinal trunks in the neighbourhood of the spiracles and supplying to the organs of that segment. In the first seven abdominal segments. the ventral branches from the ventral commissures supplying the tracheae to the ganglia and the abdominal legs and in the eighth segment they are broken into many branches ramifying the hind-gut of the alimentary canal. The dorsal branches of two sides in eighth segment unite to form a dorsal commissure.
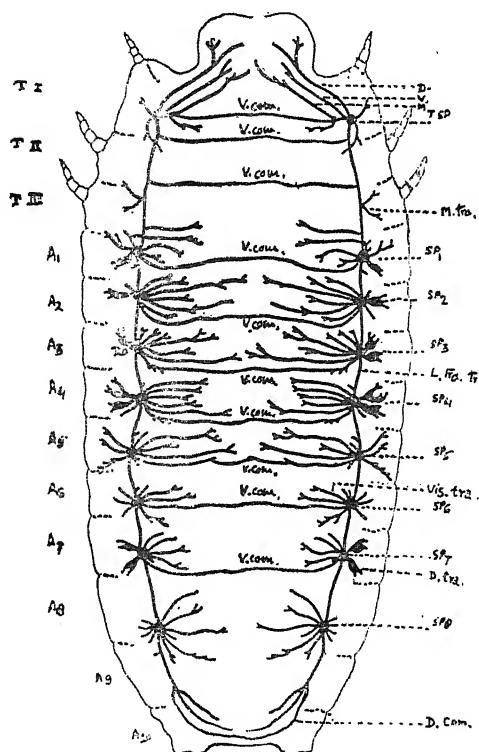
The larva of *Achoea janata* Linn. showing the teacheal system.

A_1—A_{10} Abdominal segments, SP_1—SP_8 Abdominal spiracles ;
V. com.—Ventral commissure ; D. oom.—Dorsal commissure.
T_I, T_{II}, T_{III}—Thoracic segments—, Tsp.—Thoracic spiracle ;
D, V & M—Dorsal, Ventral and Median tracheal trunks.
M. tra—Median trachea ; Vis. tra—Visceral trachea ; D. tra —Dorsal trachea ; L. tra. tr.—Lateral tracheal trunk.

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THE INFLUENCE OF VARIOUS CARBON SOURCES ON THE GROWTH OF *CERCOSPORA* SPP.

By

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The first, third and fifth papers of the series give an account of the influence of different carbon sources on the growth of *Colletotrichum capsici* (Thind and Randhawa, 1957), *Gloeosporium psidii, G. piperatum* and *Colletotrichum* sp. (Thind and Rawla, 1958) and *Alternaria brassicae* (Thind and Gill, 1961) respectively. This paper deals with the influence of various carbon sources on the growth of three species of *Cercospora* (*C. hibiscina* Ellis and Everh. *C. withaniae* Sydow and *C. crotalariae* Sacc.). Very tittle work has been done on the carbon nutrition of *Cercospora* as a genus. Perhaps *C. beticola* (Sharma, 1958), *C. mali* (Sachdeva, 1961) and *C. viticola* (Sethi and Munjal, 1963) are the only other species of which the carbon nutrition has been studied.

Materials and Methods

Cercospora hibiscina was isolated from *Hibiscus cannabinus, C. withaniae* from *Withania somnifera*, and *C. crotalariae* from *Crotalaria juncea*. Several monosporic isolates of the three pathogenic fungi were made separately on P.D.A. No morphological variation in the various isolates of the three respective fungi was observed. One representative isolate of each species was selected for further experimental work.

The basal medium used throughout the present studies had the following composition : KNO_3, 5 g ; KH_2PO_4, 5 g ; $MgSO_4. 7H_2O$, 0·5 g ; $Fe_2 (SO_4)_3. 6H_2O$, 0·005 g ; and distilled water 1,000 ml. The basal medium was divided into various lots depending upon the number of carbon compounds to be investigated and these lots were sterilized at 15 lbs./sq. inch steam pressure for 15 minutes. Various carbon compounds were dissolved separately in distilled water and were then added, after sterilization, separately and aseptically to the remainder of the various lots of the basal medium. Each carbon compound was added at a concentration to give 8 g of carbon/litre of the basal medium which amount is present in 20 g of glucose‡.

The different complete media were adjusted to pH 6 and 25 ml of each were pipetted aseptically into the sterilized 125 ml Pyrex glass Erlenmeyer flasks. The media in the flasks were seeded with 1 ml of the standardized mycelial suspension of only one of the pathogens. The media in the flasks seeded with *C. hibiscina* and *C. withaniae* were incubated at 28°C for 24 days while those seeded with *C. crotalariae* were incubated at 26°C for 12 days. Determinations of the dry weight of the mycelial growth and final pH were made as usual. The pH, incubation periods and temperatures employed above were found to be optimum for the respective fungi by preliminary experiments.

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‡Soluble starch, inulin and pectin were added each at the rate of 20 g/litre of the basal medium.

Mycelial suspensions were used as inocula in the cases of all the three *Cercospora* spp. as these did not sporulate in culture. A simple mincing and crushing apparatus (Fig. 1) was devised to prepare uniform mycelial suspensions. It consists of a glass rod with one of its ends made into a circular disc. A cotton pad enclosed in a piece of muslin is wrapped around the middle of the rod. The rod is fitted into an Erlenmeyer flask in such a way that the flattened circular end is always inside the flask and that the cotton pad also serves as a plug for the flask. A few drops of distilled water are always put inside the flask and the whole assembly is then sterilized. A little bit of aerial mycelium is introduced aseptically into the flask and thoroughly minced and crushed under the flattened circular end of the glass rod. More of sterilized distilled water is then added to give a standardized mycelial suspension of 15–20 mycelial bits per low field of the compound microscope. A separate such like assembly was used for preparing the standardized mycelial suspension of each fungus.
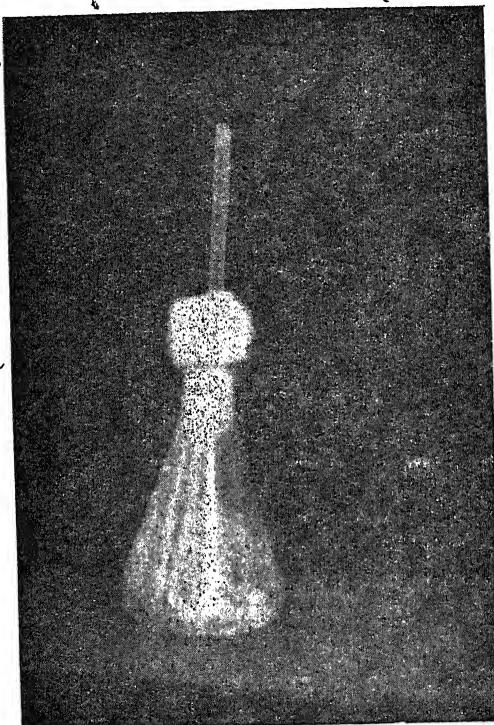
Fig 1. Apparatus used for preparation of inoculum.

The growth of the three fungi on different media has been termed good, fair or poor on the basis of their following dry mycelial weights :

Category	Dry weight, mg
Good	Above 150
Fair	70–150
Poor	Below 70

Experimental Work

Thirty carbon compounds comprising 16 carbohydrates (4 pentoses, 5 hexoses, 3 disaccharides, 1 trisaccharide and 3 polysaccharides), 2 sugar alcohols (dulcitol and mannitol) and 12 organic acids were used. The data on dry weight and final pH are summarized in Table I below.

TABLE I

Effect of different carbohydrates, sugar alcohols and organic acids used singly on the growth of C. hibiscina and C. withaniae after 24 days incubation at 28°C and on the growth of C. crotalariae after 12 days incubation at 26°C, initial pH adjusted to 6·0.

Carbon source	C. hibiscina		C. withaniae		C. crotalariae	
	Dry wt., mg	Final pH	Dry wt., mg	Final pH	Dry wt., mg	Final pH
Control (No carbon)	0	6·0	0	6·0	0	6·0
Pentoses						
D (−) ribose	45	6·4	30	6·5	25	6·1
L (−) arabinose	156	6·7	130	6·5	162	6·5
D (+) xylose	95	6·8	68	6·8	150	6·5
L (+) rhamnose	80	6·8	32	6·2	20	6·4
Hexoses						
D (−) glucose	180	6·5	176	6·4	190	6·5
D (−) fructose	76	6·7	55	6·6	200	6·4
L (−) sorbose	12	6·0	15	6·0	0	6·0
D (+) mannose	165	6·7	180	6·4	178	6·5
D (+) galactose	172	6·5	160	6·7	150	6·4
Disaccharides						
Sucrose	190	6·7	178	6·6	210	6·8
Maltose	220	6·5	200	6·5	218	6·3
Lactose	72	6·4	58	6·4	128	7·0
Trisaccharide						
Raffinose	122	6·4	105	6·4	115	7·0
Polysaccharides						
Starch	16	6·1	10	6·0	164	6·5
Pectin	125	7·1	116	7·2	104	6·7
Inulin	118	7·0	70	7·1	44	6·3
Sugar alcohols						
Dulcitol	34	6·3	16	6·1	5	6·0
Mannitol	46	6·4	45	6·6	8	6·0
Monocarboxylic acids						
Formic acid	0	6·0	0	6·0	0	6·0
Acetic acid	24	7·2	0	6·0	0	6·0

Carbon source	C. hibiscina Dry wt., mg	Final pH	C. withaniae Dry wt., mg	Final pH	C. crotalariae Dry wt., mg	Final pH
Propionic acid	12	6·5	0	6·0	0	6·0
Butyric acid	0	6·0	0	6·0	0	6·0
Dicarboxylic acids						
Oxalic acid	0	6·0	0	6·0	0	6·0
Succinic acid	35	7·1	25	6·8	0	6·0
Hydroxy acids						
Lactic acid	18	6·3	35	6·5	12	6·4
Tartaric acid	30	6·8	0	6·0	26	6·8
Malic acid	32	6·5	16	7·4	10	7·2
Citric acid	0	6·0	50	7·5	0	6·0
Glycolic acid	0	6·0	0	6·0	0	6·0
Unsaturated acid						
Maleic acid	0	6·0	28	6·5	12	6·8

It is clear from Table I that glucose, mannose, galactose, sucrose and maltose supported good growth of all the three species of *Cercospora* while ribose, dulcitol and mannitol supported their poor growth. Arabinose was good for *C. hibiscina* and *C. crotalariae* but fair for *C. withaniae*. Xylose was good for *C. crotalariae*, fair for *C. hibiscina* and poor for *C. withaniae*. Rhamnose was fair for *C. hibiscina* and poor for the other two. Fructose was good for *C. crotalariae*, fair for *C. hibiscina*, and poor for *C. withaniae*. Sorbose supported poor growth of *C. hibiscina* and *C. withaniae* and no growth of *C. crotalariae*. Lactose was fair for *C. hibiscina* and *C. withaniae* and poor for *C. crotalariae*. Raffinose and pectin supported fair growth of all the three species under study. Starch was good for *C. crotalariae*, but poor for *C. hibiscina* and *C. withaniae*. Inulin was fair for *C. hibsicina* and *C. withaniae* but poor for *C. crotalariae*. None of the organic acids used supported good growth of these three *Cercospora* spp. Formic, butyric, oxalic and glycolic acids did not support growth of any of these three fungi while the rest of the organic acids supported their poor to no growth.

Discussion

Ribose supported poor growth of these three *Cercospora* species. This sugar is reported to support poor growth of many other fungi as well. However, *Fusarium oxysporum* var. *nicotianae* (Wolf, 1955) and *Schizophyllum commune* (Swack and Miles, 1960) are probably the only fungi which have been reported so far to make good growth on it.

Arabinose supported good growth of *C. hibiscina* and *C. crotalariae* studied here. Similarly, *C. beticola* (Sharma, 1958) and *C. kikuchii* (Bloss and Crittenden, 1960) also made good growth on it. *C. withaniae* studied here made fair growth on it. Similarly, *Fusarium coeruleum* (Tandon and Agarwal, 1957) and *Alternaria brassicae* (Thind and Gill, 1961) made fair growth on it.

Xylose supported good growth of *C. crotalariae* but fair of *C. hibiscina* studied here. Many other fungi such as *Pestalotia citri* and *P. banksiana* (Tandon and Bilgrami, 1959), *Cercospora beticola* (Sharma, 1958), *C. mali* (Sachdeva, 1961) and

C. viticola (Sethi and Munjal, 1963) have been reported to make good or fair growth on it. However, *C. withaniae* studied here made poor growth on it, as is also true of many other fungi.

Rhamnose supported fair growth of *C. hibiscina*. Similarly, *Penicillium digitatum* (Fergus, 1952) and *Fusarium udum* (Subramanian, 1961) made fair growth on it. *C. withaniae* and *C. hibiscina* studied here made poor growth on it. Similarly, *C. viticola* (Sethi and Munjal, 1963), *Pestalotia banksiana* and *P. citri* (Tandon and Bilgrami, 1959) and many others also made poor growth on it.

Glucose, mannose, galactose, sucrose and maltose all supported good growth of these three *Cercospora* spp. All these sugars have been reported to be good sources of carbon for the growth of a large number of fungi. However, glucose is reported to support poor growth of *Sphaeronema fimbriatum* (Weimer and Harter, 1921) and *Melanospora zamiae* (Hawker and Chaudhury, 1946) and no growth of *Leptomitus lacteus* (Schade, 1940 ; Schade and Thimann, 1940) ; mannose of *Phytophthora infestans* (Lilly and Barnett, 1953) ; galactose of *C. viticola* (Sethi and Munjal, 1963) ; sucrose and maltose support either poor or no growth of *Leptomitus lacteus* (Schade, 1940 ; Schade and Thimann, 1940) and *Chytridium* sp. (Crasemann, 1954).

Fructose supported good growth of *C. crotalariae* and fair of *C. hibiscina* studied here. Many other fungi have also been reported to make good or fair growth on it. However, *C. withaniae* studied here made poor growth on it. Similarly, *Melanospora zamiae* (Hawker and Chaudhury, 1946) and *Fusarium udum* (Subramanian, 1961) made poor growth on it.

Sorbose supported poor growth of *C. hibiscina* and *C. withaniae* studied here. Similarly, majority of the fungi investigated so far have been reported to make poor growth on it. *C. crotalariae* studied here did not make any growth on it. Similarly, *Entomophthora* spp. (Wolf, 1951), *Phytophthora infestans* (Lilly and Barnett, 1953) and *P. fragariae* (Davies, 1959) did not make any growth on it.

Lactose supported fair growth of *C. crotalariae* and *C. hibiscina* and poor of *C. withaniae*. Lilly and Barnett (1953) and many other workers as well characterize lactose as a poor carbon source for the growth of the fungi. However, it supports good growth of *Cercospora kikuchii* (Bloss and Crittenden, 1960) and *Ceratostomella ulmi* (Gagnon, 1961).

Raffinose supported fair growth of these three fungi. Similarly, *Cercospora viticola* (Sethi and Munjal, 1963), *Alternaria brassicae* (Thind and Gill, 1961) and *Colletotrichum capsici* (Thind and Randhawa, 1957) have been reported to make fair growth on it.

Soluble starch supported good growth of *C. crotalariae* studied here. This is also true of most of the other fungi. However, *C. hibiscina* and *C. withaniae* studied here made poor growth on it. Similarly, it is reported to support poor growth of *C. beticola* (Sharma, 1958), *C. viticola* (Sethi and Munjal, 1963), and *Penicillium digitatum* (Fergus, 1952).

Pectin supported fair growth of all the three *Cercospora* spp. under study while inulin supported poor growth of *C. crotalariae* but fair of the rest of the two species. *C. beticola* (Sharma, 1958) made poor growth on both pectin and inulin while *C. mali* (Sachdeva, 1961) made good growth on pectin but poor on inulin. *C. viticola* (Sethi and Munjal, 1963) made poor growth on both.

Dulcitol and mannitol supported poor growth of all the three fungi under study, as is also true of many other fungi. However, *Alternaria tenuis* strain B

(Tandon and Grewal, 1954) is reported to make good growth on both the sugar alcohols.

These three *Cercospora* spp. either did not grow or made only poor growth on various organic acids used as the sole carbon sources. Organic acids are reported to support poor or no growth of many fungi by many workers. However, some organic acids support good growth of certain fungi such as lactic, succinic, fumaric, and tartaric acids of *Fusarium udum* (Subramanian, 1961) and succinic acid of *Alternaria brassicae* (Thind and Gill, 1961).

Summary

The carbon nutrition of three species of *Cercospora*, *C. hibiscina* isolated from the leaves of *Hibiscus cannabinus*, *C. withaniae* isolated from the leaves of *Withania somnifera* and *C. crotalariae* isolated from the leaves of *Crotalaria juncea*, was studied. The study was carried out at 28°C for 24 days in the case of *C. hibiscina* and *C. withaniae* and at 26°C for 12 days in the case of *C. crotalariae*. Initial pH of the media was always adjusted to 6·0. Influence of 30 different carbon compounds on the growth of the three fungi was investigated. Glucose, mannose, galactose, sucrose and maltose supported good growth of all the three fungi while ribose, dulcitol and mannitol supported their poor growth. Arabinose was good for *C. hibiscina* and *C. crotalariae* but fair for *C. withaniae*. Xylose was good for *C. crotalariae*, fair for *C. hibiscina* but poor for *C. withaniae*. Rhamnose was fair for *C. hibiscina* but poor for the other two. Fructose was good for *C. crotalariae*, fair for *C. hibiscina* and poor for *C. withaniae*. Sorbose was poor for *C. hibiscina* and *C. withaniae* but did not support any growth of *C. crotalariae*. Lactose was fair for *C. hibiscina* and *C. crotalariae* but poor for *C. withaniae*. Raffinose was fair for all the three species. Starch was good for *C. crotalariae* but poor for the other two. Pectin was fair for all the three while inulin was fair for *C. hibiscina* and *C. withaniae* but poor for *C. crotalariae*. Organic acids supported either poor or no growth of these three species of *Cercospora*.

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INFLUENCE OF PRE-SOAKING *VIGNA CATJANG* SEEDS IN AQUEOUS SOLUTION OF POTASSIUM GIBBERELLATE ON NITROGEN AND FREE-AMINO ACID CONTENT OF ROOT NODULES

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Reduction in nodulation in leguminous plants treated with gibberellic acid has been registered by Thruber *et al* (1958), Fletcher *et al* (1959), Radley (1961) and Singh *et al* (1964). In view of the previous findings (Singh *et al*, 1964) investigations were taken up in order to ascertain the role of gibberellic acid on the nitrogen and amino acid content of nodule during its development.

Material and Methods

Cow-pea seeds (*var.* Russian mammoth) were soaked for eight hours in concentrations of 10, 100, 200 and 400 ppm solution gibberellic acid (GA). Plants were grown in well washed sand and harvested 40 days after sowing.

Total nitrogen and soluble nitrogen, were determined by micro-Kjeldahl method. Protein nitrogen was reported as the difference between total and soluble nitrogen.

Free-amino acids were extracted from nodules in 80% ethanol and analysed by two-dimensional paper chromatography method described by Consden *et al*, (1944). 0.1% W/V ninhydrin in *n*-butanol was used as spraying reagent. After developing the chromatograms, spots were identified and located. Different amino acids were reported as area of the spots in sq. cm. after the method of Fisher *et al* (1948). The amount of solution used was 0.025 cc in each case.

Results

A slight increase in the total, soluble and protein nitrogen in the nodules of plants treated with 10 ppm gibberellic acid, was found against control. Beyond 10 ppm concentration an inverse correlation between the concentration and nitrogen (total, soluble and protein) in the nodule was recorded. Highest concentration (400 ppm) decreased the nitrogen content to the maximum extent (Table I).

TABLE I

Influence of pre-soaking of Vigna catjang seeds in aqueous solutions of potassium gibberellate on nitrogen content of nodules

(Nitrogen, mg/g)

Nitrogen	Control	GA 10 ppm	GA 100 ppm	GA 200 ppm	GA 400 ppm
Total	62·24	63·51	58·71	57·82	52·40
Soluble	12·45	13·10	11·32	9·42	7·50
Protein	49·79	50·41	47·39	48·60	44·90
% of soluble to total	20·00	20·58	19·28	16·29	14·31
Protein/soluble	3·99	3·85	4·18	5·15	5·98

A marked decrease in soluble nitrogen in the nodule of the plants treated with higher concentration of gibberellic acid, resulted in an appreciable decrease in the percentage of soluble to total nitrogen and an increased ratio of protein to soluble nitrogen (Table I).

Among the free-amino acids glycine + serine, α–alanine, γ-aminobutyric acid, leucine + isoleucine accumulated to a greater extent in the nodule of control plants. 10 ppm concentration of GA accumulated greater amount of all free-amino acids than control except glutamic acid. Higher contents of aspartic acid, α–alanine, and valine were recorded in the nodules of plants treated with 100 ppm gibberellic acid as against control, the values were less than that in 10 ppm (Table II), so that 10 ppm GA proved optimum.

TABLE II

Influence of pre-soaking of Vigna catjang seeds in aqueous solutions of potassium gibberellate on the free-amino acid content in the nodule

(100 mg/cc)

Amino acids	Area of the spot in sq. cm.				
	Control	GA 10 ppm	GA 100 ppm	GA 200 ppm	GA 400 ppm
Aspartic acid	2·85	3·55	3·12	2·45	2·10
Glutamic acid	2·78	2·93	2·41	2·10	1·50
Glycine + serine	5·21	5·65	4·86	4·25	3·40
α–alanine	5·16	6·17	5·72	4·75	4·12
γ–amino butyric acid	5·08	5·36	4·65	4·21	3·85
Valine	2·86	3·39	3·12	2·42	1·47
Leucine + Isoleucine	7·31	7·61	6·85	6·51	5·27
Arginine	3·85	3·70	3·53	2·61	2·24
Glutamine	2·65	2·14	1·45	trace	trace
U_1	3·41	3·36	2·21	3·10	1·20
U_2	2·81	2·78	2·61	2·21	1·56

A gradual decrease in each free-amino acid content accompanied the increase in the gibberellic acid concentration beyond 10 ppm. A marked reduction in all the detected free-amino acid was noted with 400 ppm concentration.

Discussion

In an earlier communication (Singh *et al*, 1964) reduced development of root nodules of *Vigna catjang* was noted by the exogenous application of GA to the seeds of the resulting plants. It accompanied reduction in the nitrogen content fo the nodules, among other things. These findings stand confirmed in these investigations also. The role of *Rhizobia* was apparently that of inducing the formation of specific nodule tissue presumably through the production of auxin (Kefford *et al*, 1960). The findings of Nutman, Thornton and Quastel (1945) indicated that auxin production was high in the region of *Rhizobia* infection. Since the action of gibberellic acid depended upon the auxin-kinetin ratio in the plant cell (Kefford and Goldacre, 1962), these findings made it obvious that gibberellic acid, at lower concentration of 10 ppm, disturbed the auxin-kinetin ratio of the root in such a manner that the capacity of the root nodule to fix more

nitrogen and to synthesize more free-amino acids, was brought about. Higher gibberellin concentrations, possibly increases the auxin content of roots causing a depressive effect on nitrogen fixation in the nodules. It may be explained with Radley (1961) that a gibberellin like substance in the root nodule was supposed to inhibit the nitrogen fixation by reducing nodular development. Exogenous application of gibberellic acid in higher concentration increased its content in the root. GA concentrations higher than 10 ppm proved to be the supra-optimal dose disbalancing the auxin-kinetin ratio, decreased nitrogen fixation, and also free-amino acid synthesis in the nodules.

Summary

Influence of pre-soaking *Vigna catjang* seeds in aqueous solution of potassium gibberellate on the nitrogen and free-amino acid content of the root nodule was studied in sand culture. While lower concentration of 10 ppm of GA proved optimum for total, soluble and protein nitrogen, as well as free-amino acid content of the nodule, higher concentrations were deleterious.

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INFLUENCE OF LONG AND SHORT PHOTOPERIODS ON EAR-EMERGENCE AND COMPONENTS OF YIELD IN WHEAT

By

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Introduction

Photoperiodic responses in the crop plants have been extensively investigated in India and elsewhere, and are reviewed by Munreek and Whyte (1948) and Withrow (1959). In India, acceleration of flowering in wheat by long photoperiods and delay by short ones has been reported by Singh *et al* (1938), Chinoy and coworkers (1949), Gupta (1953), Bhardwaj (1955) and others ; however, the influence of these treatments on the characters determining the yield has been studied by a few workers (Nanda and Chinoy, 1957). In the present investigations attempt has been made to study the photoperiodic response of two wheat types in respect of ear-emergence and components of yield.

Methods and Meterials

Seeds of two wheat types, N. P. 165 (early) and C. 13 (medium) were sown in earthen pots (9″ × 9″ dia) filled with soil mixed with garden compost (2 : 1) and plants were raised under the conditions of optimum watering throughout. Ten seeds were sown and four weeks after sowing seedlings were thinned to three per pot. At this stage, the pots were transferred to specially constructed chambers (5′ × 5′) within a glasshouse fitted with canvas curtains and florescent tubes plus 'osram' coiled-coil lamps. Adequate precautions were taken for free circulation of air. On the completion of the photoperiodic treatments, the pots were brought back to the wire enclosure for subsequent growth. The following treatments were given :

(*i*) LD : 15 cycles of 16 hours light and 8 hours darkness ;

(*ii*) ND : Normal day as prevailing under Agra conditions (10·5 hours light and 13·5 hours darkness) ;

(*iii*) SD : 15 cycles of 8 hours light and 16 hours darkness.

Observations on ear-emergence, growth and yield (including the grain-yield, number of grains and spikelets and 100-grain weight from the spike of the mother and tiller shoots) were recorded. Six replications of each treatment were maintained and the data were analysed statistically following the 'analysis of variance', on factorial basis.

Experimental Findings

Earing was enhanced by long photoperiod and delayed by short one. The differences were more marked in the medium type C. 13 (Table I)

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TABLE I

Effect of long and short photoperiods on ear-emergence in wheat

(Mean per plant per pot)

Variety	Long photoperiod (days)	Normal day (days)	Short photoperiod (days)
N. P. 165	80·1	82·8	87·6
C. 13	82·0	86·8	94·4
C. D. at 5% level	Variety 1·3	Photoperiod 1·5	Interaction Not significant

TABLE II

Effect of long and short photoperiods on growth and yield in wheat

(Mean per plant per pot)

Variety	Photo-period	Height (cm)	Leaves (no)	Tillers (no)	Shoot dry weight (g)	Grain yield (g)	1000-grain weight (g)
	LD	63·8	13·6	2·7	2·65	1·74	32·7
N. P. 165	ND	63·0	13·6	3·0	2·47	1·82	33·3
	SD	64·0	17·5	3·2	2·64	1·40	30·7
	LD	57·5	17·4	2·9	2·56	1·74	28·4
C. 13	ND	64·1	17·1	3·0	2·84	2·18	28·5
	SD	66·4	19·9	3·1	3·41	2·25	26·6
C. D. at 5% level :							
Variety ..	N. S.*	0·9	N. S.	N. S.	N. S.	1·3
Photoperiod ..	N. S.	1·1	0·2	N. S.	0·22	1·6
Interaction ..	N, S.	1·6	N. S.	N. S.	0·32	2·3

*N. S.—Satistically not significant.

Plant heights and dry matter produced by the shoots were not influenced significantly by the photoperiodic treatments (Table II). Increase in the number of leaves and of tillers was evident under SD condition but 100-grain weight was lowered.

The treatment effects on the component of yield are summarized in Table III.

TABLE III

Effect of long and short photoperiods on components of yield in wheat
(Mean per plant per pot)

Observation	N. P. 165			C. 13		
	LD	ND	SD	LD	ND	SD
(i) Spike of the mother shoot :						
Grain-yield (g)	0·78	0·95	0·74	0·99	1·09	1·04
Grain (no)	22·1	25·8	23·2	30·1	32·6	32·3
Spikelets (no)	12·8	13·8	13·4	13·3	15·7	15·4
1000-grain weight (g)	35·1	36·7	32·8	31·2	33·4	32·2
(ii) Spike of the tiller shoot :						
Grain yield (g)	0·58	0·59	0·40	0·48	0·59	0·50
Grain (no)	1·86	19·0	14·3	19·1	22·0	20·2
Spikelets (no)	12·0	14·0	9·9	12·8	14·3	14·3
1000-grain weight (g)	30·4	31·3	22·5	23·7	24·7	23·7

C. D. at 5% level :

	Spike-mother shoot			*Spike-tiller shoot*		
	Variety	Photo period	Interaction	Variety	Photo period	Interaction
Grain yield (g)	0·08	0·10	0·15	N. S.	0·09	1·3
Grain (no)	1·7	2·1	N. S.	2·5	N. S.	N. S.
Spikelets (no)	0·7	0·9	1·3	1·1	1·4	1·9
1000-grain weight (g)	1·9	N. S.	N. S.	3·1	3·8	5·4

From the plants receiving the photoperiods (long or short), grain yield of the mother shoots was depressed in N. P. 165 and was reflected in depressing the number of grains and of spikelets and 100-grain weight. In C. 13 as well, number of grains and of spikelets was lowered under LD condition. Yield of grain from the tiller spikes was affected rather erratically ; significant lowering was noticed in N. P. 165 under SD condition wherein the number of grains and of spikelets was decreased.

Discussion

Recapitulating the important results summarised in the preceding section, it is noticed that :

(i) Irrespective of variety (early or medium), the total yield of grain per plant appears to be governed by the yield of the main spike.

(*ii*) The 'medium' type (C. 13) under long day conditions, did not show any negative influence of the treatment on the yield components of the tiller spikes; on the other hand, there is a tendency for slight improvement, but this advantage has not benefitted in any way the total yield. Under short day conditions, the total yield per plant was slightly better (though statistically not significant) in spite of the significant delay of six days in the emergence of the main spike. The yield of the main spike was not altered but tiller spike yield showed slight improvement. It is plausible that under short day conditions the tillers may grow better and their yield may improve the total yield.

(*iii*) In the early type N. P. 165, slight earliness under long day condition or delay under short day condition in the emergence of the main spike did not accentuate the grain yield. Under long day condition, some of the characters of the tiller spike showed slight improvement or were not significantly lowered but still they did not influence the total yield. The short day treatment was definitely harmful for most of the characters under study.

Nanda and Chinoy (1957) also reported the lowering of grain yield both under long day and short day conditions and explained such a behaviour due to low assimilation rate under short day condition and to the influence of light on the formation of regulatory substances under long day conditions. However, the treatments of 18 hours and 6 hours day-length, adopted by the above workers, were relatively more drastic. This might explain the 'no effect' noticed on the total yield performance of the plant, though differences in respect of yield component were discernible. It is thus evident that photoperiodic treatments not only affect the 'days to flower' but also the grain setting and maturity of tillers.

Summary

1. Ear-emergence in wheat was enhanced by long photoperiods and retarded by short one, the 'medium' flowering type (C. 13) exhibited greater response than the 'early' type (N. P. 165).

2. In the 'early' type N. P. 165, yield per plant was depressed by either of the photoperiod; SD was definitely harmful for most of the yield components under study.

3. In the 'medium' flowering type C. 13 under LD treatment the yield per plant, compared to the control, was not altered in spite of slight improvement in tiller spike characters (other than grain yield); yield from the main spike was not affected.

Acknowledgements

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CLASSIFICATION OF THE GROUND WATER EXPLOITATION ZONES

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Introduction

About 75 per cent of the total population of 6·95 millions inhabiting the arid tracts of Western Rajasthan (the Thar desert) covering an area of 2,07,200 sq. km. depend on agriculture for their livelihood. Since agricultural practices in this area are almost entirely dependent upon the erratic annual rainfall of 130 to 500 mm, it is essential to tap all the ground water resources for an all-round development of the area. A systematic study of the ground water resources of the region was, therefore, commenced by the Basic Resource Studies Division of this Institute in 1960. Preliminary studies were conducted in the Central Luni Basin (25° to 26° North Latitude ; 72° to 73° East Longitude) to demarcate the present ground water exploitation zones with a view to determine the nature of the ground water potential pockets in the region and to utilise the data for locating more ground water potential pockets in similar tracts.

The principal factors used in the classification of sub-surface or subterranean water or underground waters can be divided into two groups, *viz.,* natural and artificial. The natural factors are based on the genetic factors *i.e.,* climatic, hydrological, geological, pedological and biogenic. The artificial factors are dependent on man's deliberate economic activities (Altovsky and Konoplyantsev, 1959).

On the basis of natural factors, ground waters have been generally classified into (*i*) *Kremastic water* or suspended water (Meinzer, 1942) or Vadose water (Legget, 1962) ; (*ii*) *Plerotic water* (Meinzer, 1939) or subartesian water (Legget, 1962) which has been further classified into (*a*) Perched water bodies (Meinzer, 1942), (*b*) Cannate or fossil water (Legget, 1962) and (*c*) Artesian water (Bateman, 1955) ; Legget, 1962) ; (*iii*) *Plutonic* or *Juvenile water* (Legget, 1962) and (*iv*) *Internal water* (Legget, 1962).

Although ground water is available throughout the earth's crust, economic utilization of the entire resources of a particular area has often been a problem.

Only Plerotic water, and in particular perched water bodies, can be economically utilized by people with modest means by employing manual and cattle power in the desertic tracts. Therefore, only plerotic water is dealt with in this paper. According to Siline-Bektehowrine (1961) ground water in arid zones occurs in the upper belt of the earth's crust. But very little work has been done so far to investigate whether the plerotic waters in different parts of the earth's crust are of uniform chemical composition and whether the quantities available are uniform.

WATER EXPLOITATION ZONES
(JULY - AUGUST 1961 AND JULY- OCT. 1962)

N

DHARAMSAR

RATHORON-
KI-DHANI
PACHPADRA   UTER

SIMALIA

BANKLI

JAGSON   ARTHANDI   RAMA

KHUMI KI   SACALIA
DHANI   PADRU   NIMBLA
                                            WERI
                         NIMBLIANA   DHEBAWAS
SARANA
                                            TAWA
        BAUTRA   H.
                         BAKRA   REWAT   HARJI

                              DHANPURA   MANODAN

                    KOMTAN   JAGSAN
        JAITU   LAS

                    BHINMAL   PALRI

MILES 8   4   O   8   16 MILES
                    SCALE

WATER EXPLOITATION ZONES

	RIVER TRACT
	PLAIN TRACT
	INTER MONTANE
	FOOT HILL
	INTER DUNE
	HILLS

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The availability of ground water depends upon the texture, composition and relative stability of the local rock formations and upon their structural arrangements and relationships to the neighbouring rocks (Legget, 1962). The development of plerotic water bodies involve three steps, viz. (i) infiltration of water from the surface into the soil or rock material which lies just below the land surface, (ii) downward movement of water through zone of aeration and (iii) delivery of a part of the water to the zone of saturation at the water-table. These steps are dependent on the factors relating to the precipitation and intake facilities (Meinzer, 1942).

In arid regions the scanty precipitation generally occurs as sudden downpours but these cause freshets in dry washes and give rise to ground water pockets (Meinzer, 1942).

The intake facilities of a tract are governed by the permeability and porosity of the formations. Formations such as broken lava, clean gravels or coarse sands take a large part of the precipitation leaving little or no direct runoff (Meinzer, 1942). The porosity of the crystalline rock below the weathered and fractured zone is very small and in alluvia and sedimentary material it extends to great depths. Talman (1937) states that the ground water bodies in the former case is much thinner and in the latter much thicker than 60 and 80 metres as estimated by Van Hise (1904) for these formations respectively.

The development, quality and quantity of plerotic water should have some relationship with the topography of the region and the ground waters occurring within similar geomorphic settings should have some common characteristics while those from dissimilar geomorphic settings should differ.

The Central Luni basin has practically similar climatic and geologic conditions throughout the region. An attempt has been made in this paper to study the validity of the above mentioned hypothesis for the ground water potential pockets of this region.

General hydro-geological conditions

The principal lithological formation of the region are blown sand and alluvia of the Quaternary age, secondary rock formations of the Pleistocene age, volcanics and crystalline rock formations of the Palaeozoic age and the sedimentary metamorphosed rocks of Archaean age. The primary rock formations of the region i.e. volcanics and granites are poor hosts for water accumulation (Taylor, 1955) except in the joints, planes etc. and in "gruss" in the case of granite and in weathered mantle near the surface in the case of volcanics. The volcanics contain the regional zone of saturation (Taylor, 1952).

The mantle of the ground water potential bed rock formations, over a large part of the area, are superficial deposits of fluvial sand and gravel with an extensive part of carbonates ("kankar"). These deposits are much thicker in and near the larger water courses of Luni River system and are thin or absent elsewhere. Though, generally, the regional zone of saturation lies below these deposits, even then perched water bodies of ground water occur in the aeolian sand of the dunes, fluvial sand and gravels, etc. which rest on relatively impervious bed rocks (Taylor, 1952).

Material and Method

The survey was undertaken on village basis and observations recorded on 1: 126720 scale topographical sheets prepared by Survey of India. For each village

the total number of wells along with informations regarding utilization of water, seasonal variations in taste, static water level and lithology were recorded. The locations of wells were approximately marked on the topographical sheets. On the basis of these points the ground water exploitation zones were demarcated. The wells which are for human and livestock use are known as "Pechka", those for irrigation are known as "Bera" and the small wells discussed under "river tract" subsequently are known as "Beris" in local language.

The zones so demarcated were classified according to their geomorphic settings on the basis of the following considerations :

(a) The static water level and the taste of water in the wells situated in the plain tract change very little with the seasons unless torrential downpours occur. Generally such zones are situated in secondary grits.

(b) The ground water exploitation zones in the river tract are generally developed in the alluvia. The static water level and the salinity varies with the quantity of water flown through the ephemeral channels during monsoon.

(c) The inter-dune zones are characterised by the availability of ground water at lesser depths in the stabilized sand dunes. All of the inter-dune areas are not potentially water bearing but in regions where the development of dunes have taken place near the hills, the ephemeral streams originating from the hills discharge their water. The lower stratum which is porous stores the water and thus develops into a ground water bearing formation.

(d) The inter-montane zones are characterised by their ground water bearing lithological formation. In such zones the ground water accumulation has been favoured in the rock detritus material of the hills which have filled up the inter-montane valley. In such zones the taste of ground water and static water level varies in relation to the amount of precipitation during the monsoon and also depends upon the number and width of joints, fractures etc. in the nearby hills.

(e) The foot hill zones generally developed on the weathered mantle of the primary rocks, which in this region are igneous crystalline and volcanics, or on the secondary grit deposited on the lower piedmont zone of the hills. These zones get their recharge through the joints, fractures etc. in the hill region and the variation of salinity and static water level of ground water depends upon the number and width of the joints, fractures etc. The variation generally takes place some two to three months after the mosoon.

Classification of ground water exploitation zones

The ground water potential zones of the area have been demarcated on the basis of artificial factors as proposed by Altovesky and Konoplyantsev (1959). There are in all 42 water exploitation zones in this region. These have been classified in table I.

These ground water potential zones have been shown in the map as "water exploitation zones".

(a) *General description of the various groups of water potential zones* :

(1) *Plain tract.*—These water potential pockets have probably developed in the plains due to inland drainages or streams, originating in mountainous regions at a considerable distance (Legget 1962 ; Lowdermilk, 1953),

which develop in direct response to the sudden torrential precipitation and disappear into the ground after running for a short distance. The disappearance of such streams can probably be attributed to either the lesser gradient of the plain or due to lesser run-off or else the channels of the streams may be choked by the piling up of blown sand. These water potential pockets have generally developed in younger and older alluvia. In these zones wells are made by digging a 2 to 3 metre circular or square pit until the hard "Kankar" pan or grit zone is reached. Below this zone the diameter of the pit is reduced to 1·5 to 2 metres and digging is continued till the water-table is reached. As there are no good sources of regular recharge in such regions, the bottom of the wells is excavated and made into a reservoir or side galleries of 1·5 × 1·5 metres and 3 to 5 metres long are excavated in four to six direction to increase the effective percolation and storage capacity of the well. Sometimes when the well is dug too deep i.e. below the fresh water cushion, saline water is encountered with. In such cases a false bottom to separate the sweet and saline water zones is made with the help of the logs of *Salvadora* sp. and clay. A lining is provided in each well above the grit zone, where the diameter has been reduced. The lining is generally made from the logs of *Salvadora* sp. and in some cases of cement or lime mortar with stone. This group of water potential zones is the second largest group. Though it occupies a lesser area as compared to the inter-montane area yet the total water reserves here are the second largest. The water-table is generally parallel to the surface (Fig. 1).

TABLE I

Ground water exploitation zones

S. No.	Class of zone	Total number of zones	Total area in sq. km.	p. c. of the total area	Ground water reserve in million cubic metres* Total in 100 sq. km.	
1.	Plain tract	9	316·0	2·82	10·2	3·2
2.	River tract	11	1297·3	11·71	17·2	1·3
3.	Inter-dune areas	4	176·1	1·57	6·7	3·8
4.	Inter-montane areas	6	562·0	5·01	8·3	1·4
5.	Foot hills	9	106·2	0·96	0·41	0·3
6.	Unexploited :					
	(a) Hills	—	290·0	2·58	—	—
	(b) Rest, including rising water-table tracts covering a few hectares	3	8441·2	75·35	—	—
	Total	42	11188·8	100·00	42·81	—

*The water reserves have been calculated on the basis of the formula given by Talman (1937).

(2) *River tract.*—The stream zones of this region are recharged by the torrential storms which originate as flashy and violent floods (Lowdermilk, 1953). Intake is small in inter-stream areas because the degree of runoff is relatively large due to lack of vegetation. Most of intake is from the stream as the scanty showers do not penetrate deep into the air filled pores of the desert soil. Consequently, the water

table is higher under the streams and lower away from them developing *influent* stream profile in contrast to the *effluent* stream profile of humid regions (Bateman, 1955).

Here the water potential pockets develop in the underlying porous strata of clean sand and gravels. Although such formations occur throughout the riverine tracts, water accumulation only occurs where the extent and thickness of the formation is high and their structure is favourable. The water potential pockets have developed where the channels of runoff have been dammed either by concealed or exposed rock outcrops (Saha, 1953). In these zones wells are generally dug on the bank of the rivers or a little away from the banks. A pit of 2 to 3 metres circular or square in shape, is dug till the grit zone is encountered with. Then the width is reduced to 1·5–2 metres and the pit is dug deeply till the water-table is reached. The wells are either lined with cement or lime and mortar or with logs of *Salvadora* sp. But the wells which are dug on the bed of river are only 1 metre wide and 3–5 metres deep. These are used only for human and livestock requirements during the summers when either the surface water resources have exhausted or the salinity in the ground water has increased due to over utilization of the fresh water cushion. These wells are either lined with cement or logs of *Salvadora* sp. On such wells only buckets are used to take out water, whereas other types either Pershian Wheel or mote and bull or mechanical pumps are used. This is the biggest group of water potential zones and occupies the maximum area. The water reserves are not much in this group. Such water potential pockets which are on the same channel are no doubt continuous ones but the intermediate section does not have much water potential. Therefore, only the better water potential areas have been considered as individual zones for further interpretation (Fig. 2).

(3) *Inter-dune area.*—Water potential pockets in the inter-dune areas probably develop due to lack of inland drainage in these areas. The precipitation is trapped within the zones of dunes and is stored in the previous sand stratum below the dunes which is uuderlain by an impervious "kankar" pan. In this zone wells are generally dug in a different manner. First a brick or cement lined circular pit, approximately 3 metres deep, is excavated. Then a galvanised iron pipe or cement pipe of 7·5 cm diameter and 2·5 to 3 metres long is sunk in the base. Water starts oozing out of this pipe. In some cases it has been observed that the oozing water rises nearly 30 cm or so above the base of the pit as happens under artesian conditions. Only four such water potential pockets have been identified. Though the area covered by this group is less yet ground water reserves are maximum (Fig. 3).

(4) *and* (5) *Inter-montane and Foot hill areas.*—The streams originating on the hills as a result of precipitation are partly arrested within the inter-montane basins in the former case and the foot hills in the latter case. The excess of precipitation flows out of these zones in the form of streams and rivulets. Due to the steeper slopes in this terrain than in the other tracts, water has little time to stagnate here but even then, there is a certain amount of percolation to the lower strata. This is because there is very little soil cover here and the porous stratum is composed of larger angular fragments of disintegrated rock debris. In these zones wells are dug as discussed in river tract zone. Ground water reserves in the foot hill group are the least but are appreciable in the case of the inter-montane group. The watert-able is roughly parallel to hills and valleys, although it is less accentuated. Water, therefore, will always lie closer to the surface under inter-montane area than under piedmont. (Fig. 4 and 5).

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SCHEMATIC HYDRO-GEOLOGICAL PROFILES

FIG.1. PLAIN TRACT

FIG.2. RIVER TRACT

FIG.3. INTER DUNE AREA

FIG.4. INTERMONTANE AREA

FIG.5. FOOT HILLS
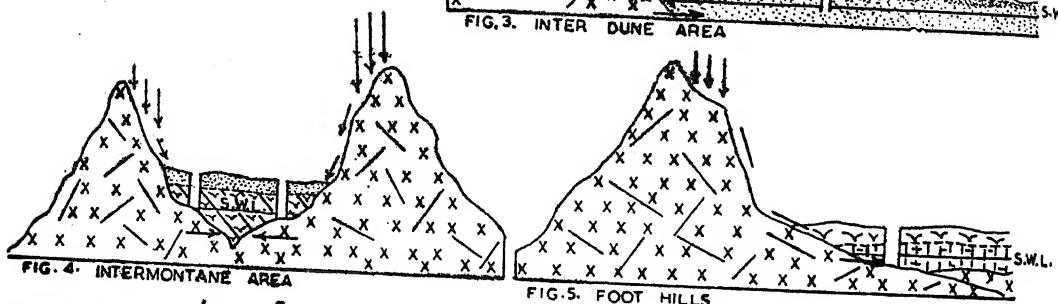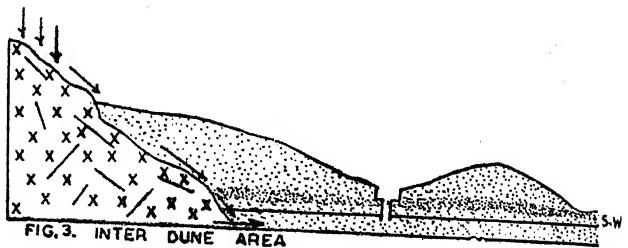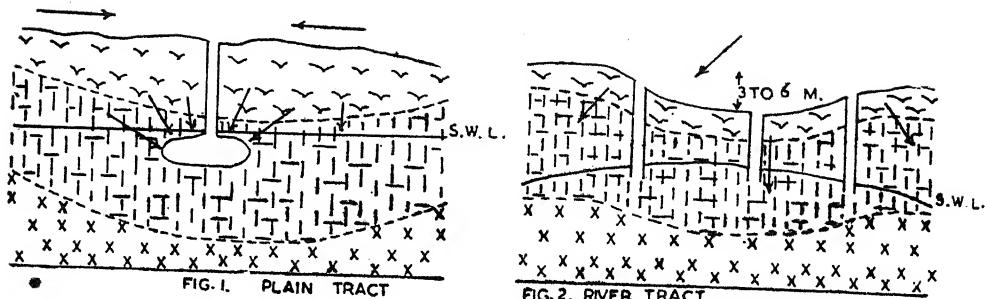
L E G E N D S

BLOWN SAND	
COMPACT CALCAREOUS LAYER OF SAND	
YOUNGER ALLUVIUM WITH ROCK DETRITUS MATERIAL	
OLDER ALLUVIUM	
IGNEOUS CRYSTALLINE OR VOLCANE ROCKS	

S.W.L.	STATIC WATER LEVEL
	JOINTS CRACKS ETC.
	YOUNGER ALLUVIUM
	DIRECTION OF RECHARGE
	WELL

TABLE II

Variation of static water level, total soluble salts and discharge potential in various water potential zones

S. No.	Class	S. No.	Group	Details of village and wells*	Static water level (in decimetres)**	Total soluble salts (in p.p.m) †	Discharge potential (per well in litres per hour)†**
1	2	3	4	5	6	7	8
1	Plain tract	1	Dharmasar—Depura	4 / (8 – N. A.)	253 / (268 – 238)	3770 / (5456 – 1364)	7000 / (14000 – 7000)
		2	Uter—Bararoshia	5 / (5 – N. A.)	203 / (259 – 140)	1808 / (2786 – 650)	8000 / (14000 – 7000)
		3	Ada—Buriwada	2 / (2 – 52)	190 / (226 – 155)	4352 / (6400 – 2304)	9500 / (14000 – 7000)
		4	Rewat—Dhanpura	3 / (3 – 62)	88 / (186 – 17)	6946	5500 / (5500 – 5500)
		5	Sapni—Wajanwari	3 / (4 – 98)	91 / (104 – 76)	1138 / (11840 – 3200)	7000 / (5500 – 5500)
		6	Aipura—Weria	1 / (2 – 9)	73	4934 / (1536 – 822)	7000 / (9000 – 5500)
		7	Sankwali—Chandrai	5 / (7 – 230)	47 / (60 – 21)	2778 / (4480 – 1024)	8000 / (14000 – 5500)
		8	Arniala—Sarana	7 / (8 – 35)	124 / (170 – 60)	4805 / (7680 – 1188)	11300 / (22700 – 11300)
		9	Kawatra—Jaitu	2 / (2 – 36)	99 / (128 – 70)	2899 / (4544 – 1254)	7000 / (7000 – 7000)
	Average			3·5 / (4·5 – 69·1)	129 / (268 – 21)	3914 / (11840 – 650)	7800 / (22700 – 5500)

S. No.	Class	S. No.	Group	Details of village and wells*	Static water level (in decimetres)**	Total soluble salts (in p.p.m.)†	Discharge potential per well in litres per hour)†**
1	2	3	4	5	6	7	8
2	River tract :						
	(a) River Luni	1	Samdari—Tigri	4 (11 – N. A.)	70 (94 – 30)	2790 (8707 – 870)	25000 (72700 – 7000)
		2	Balotra—Bithuja	7 (5 – 100)	62 (104 – 18)	2873 (10912 – 678)	14000 (36400 – 7000)
	(b) Sukri Nadi	3	Reora—Bankli	2 (7 – N. A.)	49 (55 – 43)	2348 (3530 – 1167)	14000 (14000 – 14000)
	(c) River Jawai	4	Jalore—Mandwala	6 (8 – 574)	48 (128 – 37)	1604 (2880 – 474)	7700 (14000 – 5500)
		5	Ahor—Harji	5 (11 – 546)	78 (113 – 49)	1171 (2048 – 614)	5500 (5500 – 5500)
		6	Kotra—Bharunda	8 (10 – 417)	37 (67 – 21)	2128 (5248 – 544)	5500 (5500 – 5500)
		7	Saila—Surana	14 (13 – 512)	51 (128 – 0)	4602 (22400 – 640)	8000 (14000 – 7000)
	(d) Kharioti Nadi	8	Modran—Bakra	5 (6 – 272)	66 (85 – 46)	2511 (4820 – 832)	7700 (14000 – 5500)
		9	Sena—Santhu	4 (6 – 476)	32 (43 – 21)	3286 (6528 – 632)	7000 (11000 – 5500)
	(e) Krishoti Nadi	10	Mandwara—Raipura	4 (4 – 88)	23 (30 – 18)	926 (1376 – 493)	5500 (5500 – 5500)
	(f) Bandi Nadi	11	Kalapura—Khanpur a	6 (6 – 167)	69 (95 – 40)	4209 (8979 – 383)	7700 (14000 – 5500)
	Average			5·9 (7·9 – 286·5)	53 (128 – 0)	2585 (22400 – 383)	9800 (72700 – 5500)

S. No.	Class	S. No.	Group	Details of village and wells*	Static water level (in decimetres)**	Total soluble salts (in p.p.m)†	Discharge potential (per well in litres per hour)†**
1	2	3	4	5	6	7	8
3	Inter-dune area	1	Padru—Nauria	5 (5 – 96)	160 (433 – 43)	2113 (4296 – 672)	9500 (14000 – 7000)
		2	Bhagwana-Nimblana	3 (3 – 58)	97 (168 – 34)	2821 (4480 – 1632)	7000 (7000 – 7000)
		3	Jagsan	1 (1 – N. A.)	165	3200	15000
		4	Khumi-Ki-Dhani	1 (1 – 1)	186	10880	7000
			Average	2·5 (2·5 – 38·7)	152 (433 – 34)	4753 (4480 – 672)	9600 (14000 – 7000)
4	Inter-montane area	1	Meli—Siwana	28 (28 – 775)	77 (240 – 30)	26 2 (8000 – 576)	16000 (80000 – 7000)
		2	Mailabas	1 (4 – 36)	43	934	5500
		3	Taleta—Las	3 (3 – 92)	88 (91 – 76)	974 (1664 – 542)	5500 (5500 – 5500)
		4	Mosal—Bheu	1 (21 – 51)	21	832	5500
		5	Rarbara—Chotila	1 (2 – 33)	91	614	5500
		6	Utamara—Palri	3 (3 – 158)	36 (46 – 21)	1397 (1504 – 1344)	5500 (5500 – 5500)
			Average	6·1 (10·1 – 286·2)	59 (240 – 21)	1237 (8000 – 542)	7300 (80000 – 5500)

S. No.	Class	S. No.	Group	Details of village and wells*	Static water level (in decimetres)**	Total soluble salts (in p.p.m)†	Discharge potential (per well in letres per hour)†**
1	2	3	4	5	6	7	8
5	Foot-hills	1	Rajanwari—Pandargarh	$\dfrac{1}{(2-6)}$	158	538	5500
		2	Mera	$\dfrac{1}{(1-N. A.)}$	110	717	5500
		3	Rewara	$\dfrac{1}{(1-20)}$	37	845	5500
		4	Rama	$\dfrac{1}{(1-N. A.)}$	198	1766	14000
		5	Sagalia—Nosra	$\dfrac{1}{(3-N. A.)}$	24	831	7000
		6	Bagunda—Ninbla	$\dfrac{2}{(3-N. A.)}$	$\dfrac{163}{(201-125)}$	$\dfrac{1694}{(2392-996)}$	$\dfrac{9500}{(14000-7000)}$
		7	Manadra	$\dfrac{1}{(1-25)}$	30	4608	5500
		8	Pejopura—Tarwa	$\dfrac{1}{(2-16)}$	51	2688	5500
		9	Naranwa—Dhaola	$\dfrac{1}{(2-7)}$	168	2880	5500
	Average			$\dfrac{1·1}{(17-N. A.)}$	100	1840	7100

†The discharge potential has been calculated on the basis of mode of irrigation adopted and the approximate working hours per day. For Persian Wheel, 5500 litres per hour and for Mote and Bull $180 \times \dfrac{60}{t}$, where t is the time taken in completing a cycle in minutes, h litres per hour has been taken as the basis for calculation. Where pumping sets are installed, the discharge potential was recorded on the basis of information obtained.

*The numerator denotes number of wells sampled for the group, and the denominator represented in parenthesis indicates number of villages and number of wells in that group.

**The numerator denotes the average and that in the denominator indicated within parenthesis represents maximum and minimum values observed in that group.

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(6) *Rising water-table tracts*.--In some areas, the ground water has come upto the surface and has formed permanent surface water basins. Water continues to remain on the surface throughout the year. A detailed study of these areas has not been undertaken except for the determination of total soluble salts and pH. These localities are :

S. No.	Location	Total soluble salt (p.p.m.)	pH
1.	Between Katoli and Dharwana	7040	8·7
2.	Between Arodor and Sagalla	2112	8·5
3.	Between Baliana and Dharna	3456	7·6

The total area under the three rising water-table tracts in this region covers only a few hectares and, therefore, this has not been treated separately and is included under "Rest" in table I.

(b) General Analysis :

The average total soluble salts and discharge potentials of the different groups are given in table II. The static water level is least in the case of the river tracts and maximum in the case of inter-dune areas. The average discharge potential is maximum in the case of river tracts and least in the case of foot hills.

The mean soluble salts is the least in case of the inter-montane areas and hence considering this value as standard, the total soluble salts of other zones have been statistically examined.

TABLE III

*Statistical analysis of total soluble salt contents in different types of water potential zones**

S. No.	comparison between Inter-montane area and—	't' value	'P' value
1.	River tract	7·265	<0·001
2.	Plain tract	24·722	<0·001
3.	Foot hills	0·56	not significant
4.	Inter-dune area	30·80	<0·001

It is quite apparent from data in table III that the total soluble salt contents in the case of inter-montane and foot hill areas are not significantly different. Distribution of total soluble salts is shown in the map entitled "Salinity Hazards." 16·4 per cent of the area has no salt hazard, 25 4 per cent has slight, 34·3 per cent has medium and 21·3 per cent area has high salt hazard. 2·6 per cent of the area is under hills.

*The following standard statistical abbreviations have been used in the tables III, IV and V.

t = Student's 't'	Z = Fisher's "Z" (transformed value of r)
P = Probability level	SD = Standard deviation
r = Coefficient of correlation	n = Number of pairs or observations or sample size.

SALINITY HAZARD

(JULY - AUGUST 1961 AND JULY - OCT 1962)

DHRMSAR
RAT HORON KI DHANI
PACHPADRA
SIMALIA
ARTHANDI
DHEBAWAS
BAUTRA
BHINMAL

MILES 4   0   8   16 MILES
SCALE

NO SALT HAZARD. WATER FIT FOR IRRIGATION

SLIGHT SALT HAZARD. TO BE USED FOR IRRIGATION WITH CAUTION. MANAGERIAL PRACTICES TO BE ADOPTED

MEDIUM SALT HAZARD. WATER IN GENERAL NOT SUITABLE FOR IRRIGATION

HIGH SALT HAZARD. WATER UNFIT FOR IRRIGATION

HILLS

BY
P. C. CHATTERJI
AND
A. K. SEN

CARTOGRAPHIC LABORATORY
C. A. Z. R. INST
JODHPUR

C.T.A.

TABLE IV

Statistical relationship between static water level and total soluble salts in different types of water potential zones

S. No.	Group	'r' value	't' value	'P' value
1.	Inter-montane area	− 0·009	0·005	<0·500
2.	River tract	− 0·16	1·303	<0·100
3.	Plain tract	− 0·47	3·305	<0·001
4.	Foot hills	− 0·20	0·56	<0·500
5.	Inter-dune areas	+ 0·37	1·213	<0·200

From table IV it is quite apparent that a relationship exists between depth of static water level and total soluble salt contents in the case of plain tract $(P < 0·001., r-0·47)$; while in other cases the relationship does not hold good. Except in inter-dune areas, in all other types of water potential zones the relationship between the static water level and total soluble salt is negatively correlated, indicating that there is a regular salt concentration in the inter-dune areas.

TABLE V

Significant levels of correlation coefficients of static water level and total soluble salts in different types of water potential zones

S. No.	Group	'Z' value	$SD = \dfrac{1}{n-3}$	In comparison to entire region 't' value	In comparison to entire region 'P' value
1.	Inter-montane area	0·050	0·02	1·2	>0·400
2.	River tract	0·161	0·01	1·6	>0·200
3.	Plain tract	0·51	0·04	0·7	>0·500
4.	Foot hill	0·205	0·14	4·4	<0·001
5.	Inter-dune areas	0·380	0·14	1·2	>0·200

In table V a comparison of the behaviour of static water level and total soluble salts of different types of water potential zones in the entire region $(Z = 0·107 ; SD. = 0·003)$ is shown. It appears that all the tracts have their own distinctive pattern of its relationship and the individual variations are such as to baffle any attempt to give a composite picture of the whole region by any generalized statement of this relationship.

(c) *Behaviour of static water level and discharge potential in different groups of water potential zones :* *

   (1) *Plain tract* — The average static water level is the least in the case of Aipura—Weria group and maximum in the case of Dharmasar—Depura group. It

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*The data in this section is based on the observations taken in 2590 sq.km. covered by Survey of India sheet 45 C/NE, during the month of July—August 1961 and for the remaining part of the area covered in Survey of India sheet 45 C *i.e.* 45 C/SE., NW, and S. W. during the months July—October 1962. The total soluble salts given are based on electrical conductivity.

is below 100 decimetres in the case of Rewat—Dhanpura, Sapni—Wajanwari, Sankwali—Chandrai and Kawatra—jaitu groups along with Aipura—Weria group. The average total soluble salts is below 1200 p.p m. in the case of Sapni—Wajan-wari and below 2000 p.p.m. in the Uter—Bara Roshia groups. In the other groups, the salt contents are high enough. As regards the average discharge potential, the highest discharge is of Anriala—Sarana group and the lowest is in the case of Rewat—Dhanpura group.

(2) *River tract.*—The average static water level is below 100 decimetres in all the zones. In 50 per cent of the zones, it is below 50 decimetres. The average total soluble salt content is below 1200 p.p.m. in the case of Ahor—Harji and Mandwara—Raipura groups and below 2000 p.p.m. in the case of Jalore—Mand-wala group. In all other cases, it is higher than the former areas. Such high values are due to the fact that some of the wells have appreciably higher salt content in these zones but in fact the majority of wells have low salt concentration as would be apparent from the minimum values recorded in the various zones.

The average discharge potential is highest in the case of Saila—Surana group and lowest in the case of Balotra—Bithuja and Reora—Bankli groups. But in the Jalore—Mandwala, Modran—Bakra and Kalapura—Khanpura groups, the dis-charge potential is approximately equal to the highest average value. The less total soluble salt content and greater discharge is due to the fact that the extent of porous rock formation below the river tracts is more and practically every year these zones are recharged.

(3) *Inter-dune area.*—The average static water level is below 100 decimetres only in case of the Bhagwan—Nimblana group. In all other cases it is below 200 decimeters. The average total soluble salt content in all areas is more than 2000 p.p.m. The discharge potential is maximum in the case of Jagsan zone and least in the case of Bhagwan—Nimblana and Khumi-ki-Dhani zones. The least water potential of this group can be equated to the high discharge potential of the other groups. The high salt content is due to the fact that there is very little annual recharge while the greater discharge potential can be attributed to the fact that water in such types of zones accumulates in the loose sand which has greater porosity and permeability.

(4) *and* (5) *Inter-montane and Foot hill areas.*—In the inter-montane areas the average static water level is below 100 decimetres in all cases. Except in the Meli—Siwana and the Utamara—Palri zones, the total soluble salt contents in other zones are less than 1200 p.p.m. In the former group it is over 2000 p.p.m. while in the latter it is below 2000 .p.p.m. Actually in 18 out of the 28 wells sampled, the total soluble salt contents are less than 2000 p.p.m. Of these 14 wells have less than 1200 p.p.m. of total soluble salts. The high average of total soluble salts is due to the fact that some of the wells in this group have high total soluble salts contents. The discharge potential of the Meli—Siwana group is the highest of all the groups in different classes. In other groups, it remains prac-tically the same.

In the case of foot hills, the average static water level is below 100 decime-tres in Rewara, Sagalia, Nosara, Manadara and·Pejopura—Tarwa groups, while in other cases it is below 200 decimetres. The total soluble salt contents are less than 1200 p.p.m. in the Rajanwari—Pandargarh, Mera, Rewara and Sagalia—Nosar groups and below 2000 p.p.m. in case of Rama and Bagunda—Nimbla groups. In other cases it is high. The discharge potential is maximum in the case of .

Rama group. In the other groups, excepting the Sagalia—Nosra and the Bagunda—Nimbla groups, it is low and practically the same. The low salt concentration is due to the fact that such zones are recharged practically every year irrespective of the precipitation, unless, of course, there is a total failure of rains. Secondly the rain water, immediately after the first monsoon showers, starts percolating without flowing for a long distance through the soil mantle and hence is less contaminated with salts. The high discharge potential is due to the good water bearing lithological formation in these zones.

Summary

With a view to delineate the water exploitation zones in the arid parts of Western Rajasthan surveys were conducted in the Central Luni Basin (Lat. 25°–26°N ; Long. 70°–73°E). Forty-two water exploitation zones have been demarcated and classified on the basis of their geomorphic settings as follows : plain tract—9, river tract—11, inter-dune area—4, inter-montane area—6, foot-hill—9, and rising water table tract—3. The potential of water exploitation zones and the quality and quantity of water available is directly related to the lithology and structure of the region. The principal lithological formations of the region are sand, alluvia, volcanics and granite. The primary rock formations of volcanics and granites are very poor hosts for water accumulation. The high water potential zones exist in the sand and alluvial tracts.

The average static water level is 53 decimetres in the case of river tracts, below 100 decimetres in the case of inter-montane and foot-hills and above 100 decimetres for the rest. The average total soluble salt content is 2,000 p.p.m. in the case of inter-montane and foot-hill areas while for the rest it is between 2000 p.p.m. to 5000 p.p.m. The average discharge potential per well in litres per hour is maximum, of the order of 100,000 litres, in the case of river tracts while for others it varies from 7,000 to 10,000 litres.

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BUCCO-PHARYNGEAL REGION OF LABEO DERO (HAMILTON)

By

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Introduction

Bucco-pharyngeal region of *Labeo dero* has been worked out by Mazumdar and Saxena (1961). While carrying out the routine morphological and histological studies, the present authors detected that the structures described by Mazumdar and Saxena (1961) for *Labeo dero* appeared to be much different from those observed in our material. Consequently, a detailed study of the bucco-pharyngeal region of *Labeo dero* was undertaken. The results obtained are noteworthy and are, therefore, being reported.

Bucco-pharyngeal region of the cyprinoid fishes has been studied in great detail by a number of research workers, prominent among those are Al-Hussaini (1945, 1946, 1947 and 1949), Kapoor (1954), Srivastava (1958), Sarbahi (1939), Girgis (1952), Das *et al* (1956). These works have been of immense help to us in pursuing our studies.

Meterial and Methods

Labeo dero is commonly found in the rivers of Doon Valley and is essentially a hill-stream fish as it shows a number of adhesive modifications. Alive specimens were procured from the river Assan, a tributary of the Jumuna near Herbartpur and from river Susva near Kansroo. The length of the specimens obtained ranged from 30 to 36 cm.

For working out the morphological studies, the fish were immediately fixed in 5% formalin after widening the mouth opening on the sides. For histological studies, the material was fixed in Bouin's and Zenker's fluids. After usual dehydration and embedding, sections 6 to 8 micra thick were cut. Delafield's and Heidenhain's iron-haematoxylin were employed as stains. Counter-staining was done with alcholic eosin. Diagrams were sketched with the help of a camera lucida. Minute delails were added freehand.

Observations

Morphology : Mouth is situated at the tip of the snout but is slightly inferior. It is crescentic in outline (Fig. 1). The lips are large and fleshy and help in adhesion. Both the lips bear several rows of papillae. Those of the first and the outermost tier are large and elongated, while the remaining are rounded.

The mouth leads into buccal cavity which is dorso-ventrally compressed. A flat maxillary valve is attached to the upper edge of the mouth. Roof of the buccal cavity starts curving after a short distance and the floor is slightly raised. Thus the roof and the floor come quite close to each other, leaving only a narrow space for the passage of food and water.

The mucous lining of the buccal cavity is furnished with numerous folds. The arrangement of folds is different in the roof than that of the floor. In the roof, there are two major folds which superficially divide the region into three parts. These parts are futher provided with minor folds. The minor folds of the leteral sides are longitudinally arranged but those of the central part are haphazardly disposed. The floor of the buccal cavity is provided with transverse folds which curve downward laterally. The folds of the lateral sides of the buccal cavity are appreciably raised.

In the roof of the buccal cavity, there occurs a lamellar plate-like structure (Fig. 1, l. o. p.). It hangs from the posterior half of the roof. It extends backwards almost up to the end of the buccal cavity. The organ is somewhat oval but the ends are conspicously pointed. The structure is composed of a number of lamellae arranged in two rows. The free margins of each lamella has many papillated projections which give the appearance of a small comb to it. Along the lateral sides of the lamellar organ of palate, there are observed two to three muscular folds. These are somewhat triangular in outline, the apices being pointed backwards.

The buccal cavity broadens out posteriorly and passes into the pharynx which is also dorso-ventrally flattened. Pharynx consists of two distinct regions— the anterior and the posterior pharynx. The anterior pharynx is much larger than the posterior one. Both are different from each other in structure as well as in function.

The anterior pharynx comprises of about four-fifth of the entire pharynx. The roof of the anterior pharynx is somewhat concave. The floor is, however, slightly raised. The anterior border of the roof of the anterior pharynx is V-shaped. It is divided into two symmetrical lobes by a shallow median groove. Leaving aside a small anterior portion, the entire roof of the anterior pharynx is furnished with a number of papillae which are of various sizes. The roof is supported by the base of the cranium and the traingular floor is supported by hypobranchial and the basibranchials. The anterior pharynx is perforated latero-ventrally by the gill-slits, and thus the pharynx communicates with the branchial chamber. Minute gill-rakers project into the pharyngeal cavity and serve to filter the water which passes out into the branchial chamber and bathes the gills. The gill-rakers of the outermost row rest against the operculum. The rakers are closely set up processes and each series fits into the series of the adjoining arch.

The anterior pharynx leads into the posterior pharynx. The roof of the posterior pharynx is much shorter than the anterior pharynx. This is in the form of a horny pad. It is supported by the occipital region of the skull. It is somewhat round in outline. The median part is elevated towards the floor. Floor of the posterior pharynx is thin and provided with a thin mucous lining. Two pharyngeal bones are present in the ventro-median line of the posterior pharynx. Each pharyngeal bone is armed with one set of teeth. The teeth are closely set against each other, so that the crushing of the food material becomes easy. The teeth are arranged in three rows in the order of 3, 3, 5/5, 3, 3. The teeth are homodont and the dentition is of the polyphyodont type.

Each functional tooth consists of two parts—basal part and the crown. The basal part or the root is embedded in the mucous membrane and ankylosed at its base with the pharyngeal bone. The root is narrow above but broadens out at its base. It is hollow and contains a large pulp cavity. The upper part or the crown is laterally compressed and projects into the pharyngeal cavity. The grinding surface of each tooth in plain and is devoid of hooks or cerrations,

Histology : In a transverse section of the buccal cavity two layers, *i.e.*, mucosa and sub-mucosa are observed. Muscularis *is* poorly developed (Figs. 2 and 3). Mucosa consists of thick stratified epithelium. The epithelial cells are arranged in eight to fifteen layers. The cells of the outermost layer are somewhat polygonal and compactly arranged, but those of the deeper layers are to some extent loosely arranged. The epithelial cells are somewhat rounded. The cells of the last layer are, however, oval in outline. The cells of the innermost layer rest on a basement membrane. The nuclei of all the epithelial cells are rounded and stain deeply with haematoxylin. The cytoplasm, which stains lightly with eosin, is granular.

A number of taste buds are observed to be scattered here and there in the stratified epithelim. The taste buds are flask-shaped and open to the outside by a pore. Each taste bud or gustatory organ is made up of ten to fifteen gustatory cells. The cells are somewhat elongated and their outer borders are drawn out into thin slender cytoplasmic processes. The nuclei, as usual, are rounded, deeply-stained, and placed at the centre of the gustatory cells. Besides the gusta-tory cells in the taste bud, a number of smaller and somewhat rounded cells are observed at the base. These cells, probably, support the gustatory cells and are, therefore, called sustentacular cells. Each taste bud rests on a lamina propria which is a finger-shaped outgrowth of the sub-mucosa. The taste bud receives its blood and nerve supply from the lamina propria. Besides the fully-formed taste buds opening to the outside, a number of developing taste buds are also present which are more or less circular, consist of fewer gustatory and sustentacu-lar cells, deeply located in the stratified epithelium and do not open to the outside. The taste buds are fewer in the anterior part of the buccal cavity but gradually increase in number in the posterior part.

Besides the taste buds, few mucous cells are also observed to be scattered here and there in the epithelial cells. The mucous cells open to the outside and are, therefore, located at the surface of mucosa. They are invariably filled with mucus which stains light-blue with haematoxylin. The nuclei of the mucous cells are very much flattened and lie at their bases, as if pushed by the pressure of a large quantity of mucus inside these. A number of ovoid cells are also observed scattered here and there in the mucosa and the staining reaction is altogether similar to the connective tissue cells of the sub-mucosa. Their func-tion, however, is not ascertained and are termed simply the wandering cells.

The basement membrane, which supports the mucosa, consists of connective tissue fibres and is very thin.

Below the basement membrane appears the areolar sub-mucosa. It consists of loosely arranged connective tissue cells and fibres. On the outer surface, the sub-mucosa is thrown into a number of folds which invaginate the mucosa and carry the nerve and the blood supply for the gustatory organs.

The loose connective tissue cells of the sub-mucosa are oval in outline and bigger in size in comparison to the epithelial cells of mucosa. Each cell has a nucleus which is circular and is placed towards the side of the cell.

Scattered in the sub-mucosa occur blood capillaries and the fine branches of the nerves. Moreover, sub-mucosa is comparatively thicker than the mucosa. It has been also observed that the outer part is rather dense and the inner part becomes gradually much more loose.

The structure of the roof of the buccal cavity (Fig. 3) is much similar to the floor (Fig. 2) although a few differences have been observed. In the first place, the basement membrane in the roof is a little thicker than that observed at the floor. Secondly, the mucous cells are more in number and also larger than the mucous cells of the floor; moreover, the nuclei in the mucous cells of the roof are present towards the sides of the cells, whereas in the floor, the nuclei of the mucous cells are pushed towards the bottom of the cells. And lastly, the taste buds in the roof are fewer.

There occurs a lamellar organ in the roof of the buccal cavity to which reference has already been made while dealing with the morphology. A section passing through the lamellar organ shows the usual two layers—mucosa and sub-mucosa (Fig. 4).

The mucosa of the lamellar organ is thrown into numerous folds, having many layers of striated epithelial cells. The mucous cells are very conspicous in the region of the folds. They are in abundance and very much bigger in size in comparison to those present in the floor of the buccal cavity. At the first sight it appears as if there is a continuous layer of mucous cells. Each mucous cell is elongated and the cytoplasm is reticulate. The nucleus of each cell is situated at the base as usual. The staining reaction of these cells is, however, similar to other mucous cells. The outermost epithelial layer is frequently interrupted at places as the characteristic mucous cells open to the outside.

Taste buds are fewer; as a rule one fold has one taste bud and some may have none. The taste bud is generally located at the crest of the fold and is flask-shaped.

The basement membrane, as usual, is very thin. It is supported on its inner side by a thick stratum compactum. The latter is wavy and comprises of homogeneous connective tissue fibres. Among the circularly disposed connective tissue fibres are scattered few small connective tissue cells which may be round or oval.

Below the stratum compactum, there occurs the usual sub-mucosal tissue and the details are not different from those of the rest of the buccal cavity. The particular point of interest is that in the lamellar organ the lamina propria forms gradual invaginations only in the region of the folds. The stratum compactum is also folded and takes part in the formation of the lamina propria.

The histological structure of the pharynx is quite similar to that of the buccal cavity. The entire coat is made up of mucosa and is followed by sub-mucosa (Fig. 5). However, there are certain differences which are noteworthy. The mucosa of the roof of the anterior pharynx is thrown into numerous folds. It consists of stratified epithelium. The epithelial cells of the outermost layer are slightly bigger than the cells of the inner layers. Among the epithelial cells, scattered here and there, are observed a few wandering cells. These cells are oval with granular cytoplasm and somewhat rounded nuclei placed towards the sides. The mucous cells are hardly to be seen. On the contrary, taste buds are in abundance. Even one fold sometimes may have more than five taste buds. The taste buds are flask-shaped but the neck is rather small. They open to the outside by a gustatory pore. As usual two types of cells are observed—gustatory and sustentacular cells.

Muscosa rests on a distinct basement membrane; stratum compactum is conspicuously absent. The sub-mucosa has the usual structure.

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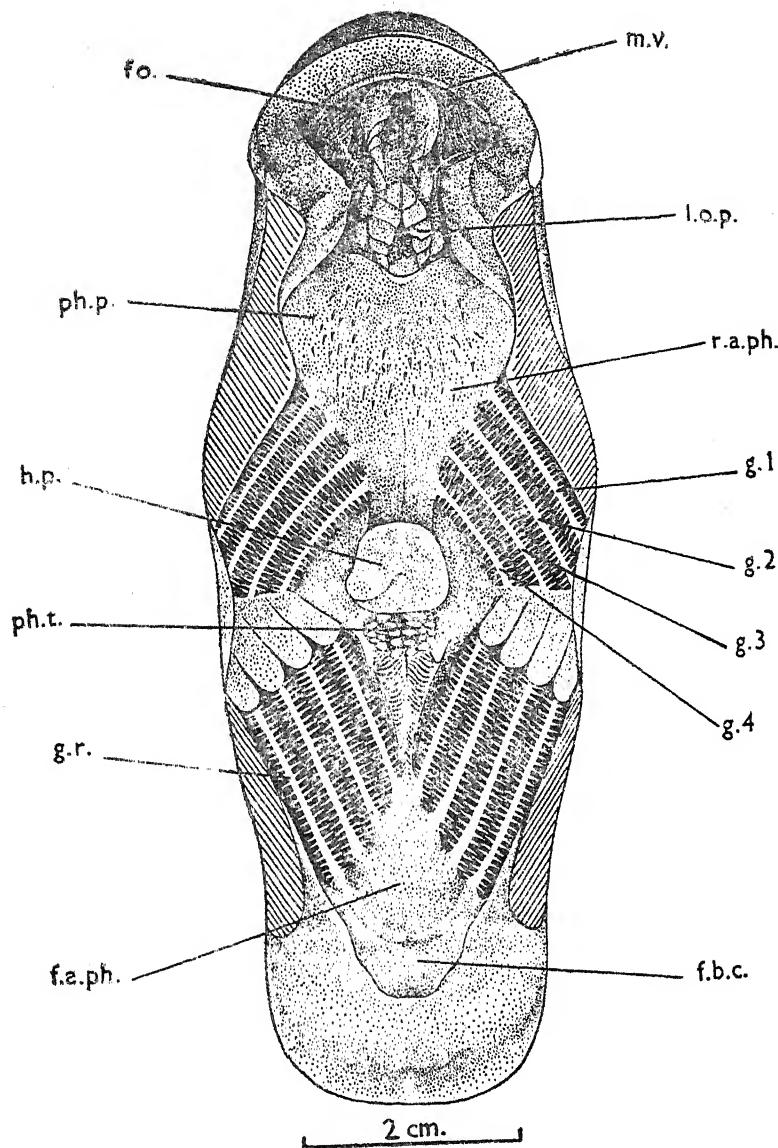
Fig. 1. Bucco-pharyngeal region of *Labeo dero* (Jaws expanded).
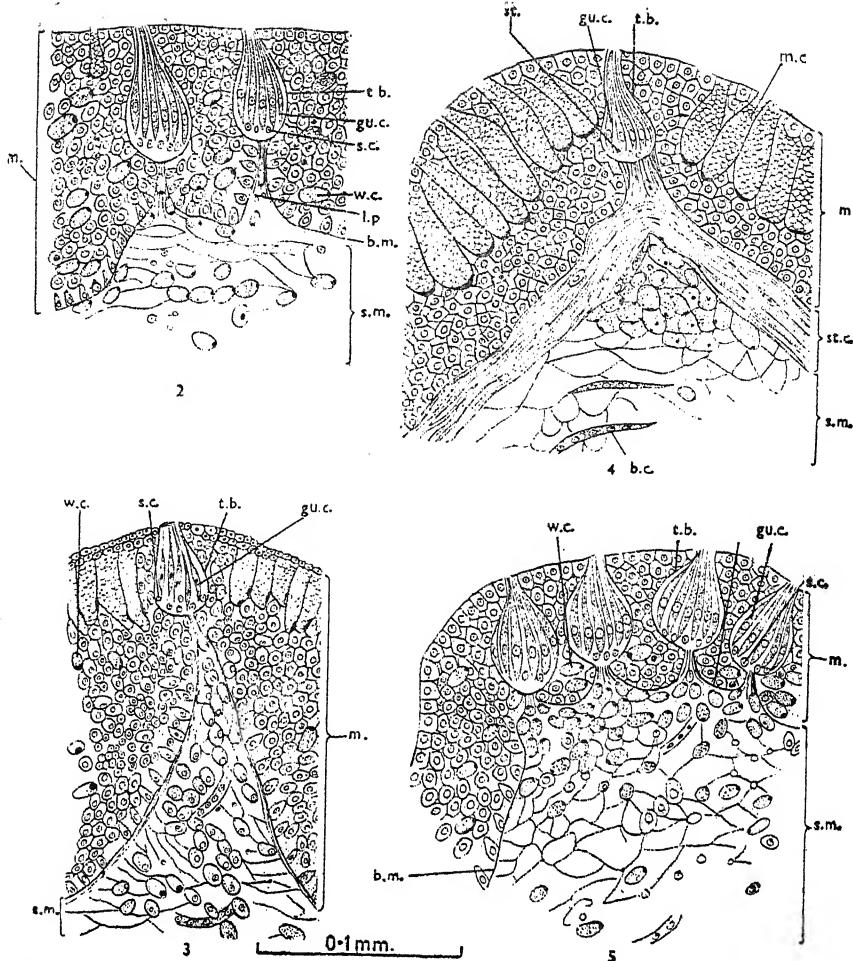
Fig. 2. A part of the transverse section of the floor of the buccal cavity of *L. dero.*
Fig. 3. A part of the transverse section of the roof of the buccal cavity of *L. dero.*
Fig. 4. A part of the transverse section of the lamellar organ of the palate of *L. dero.*
Fig. 5. A part of the transverse section of the roof of the pharynx of *L. dero.*

LIST OF ABBREVIATIONS

b.c.—Blood capillary ; b.m.—Basement membrane ; c.t.c.—Connective tissue cell ; fo.—Folds ; f.a.ph.—Floor of the anterior pharynx ; f.b.c.—Floor of the buccal cavity ; g^1, g^2, g^3, g^4—Gill arches ; g.r.—Gill-rakers ; gu.c.—Gustatory cell ; h.p.—Horny pad ; l.o.p.—Lamellar organ of palate ; l.p.—Lamina propria ; m.—Mucosa ; m.c.—Mucous cell ; m.v—Maxillary valve ; ph p.—Pharyngeal pad ; ph.t.—Pharyngeal teeth ; r.a.ph.—Roof of the anterior pharynx ; r.b.c.—Roof of the buccal cavity ; s.c.—Sustentacular cell ; sm.—Sub-mucosa ; st.c.—Stratum compactum ; t.b.—Taste bud ; w.c.—Wandering cell.

Stratum compactum is reported to occur in the buccal cavity by Girgis (1952) in *L. horie*, and by Islam (1951) in *Rita rita, Ophiocephalus gachua* and *Cirrhina mrigala*. Al-Hussaini also reports the occurrance of stratum compactum in certain cyprinoid fishes (1949). A similar sturcture has also been observed by Kapoor (1953) in *Wallagonia attu*. Girgis (1952) refers the stratum compactum to be a part of mucosa while Kapoor (1953) calls it a part of sub-mucosa. But as the stratum compactum consists of connective tissue fibres, which are circularly disposed, it should form a part of sub-mucosa and not of mucosa as stated by Girgis (1952). The present authors agree with the views of Girgis (1952).

Scattered here and there are observed few wanding cells in the mucosa of the buccal cavity of *L. dero*. These cells appear like the loose connective tissue cells. They probably take their origin form the sub-mucosal layer as similar cells are present in abundance in the sub mucosa. Their function is, however, not clearly understood.

Morphologically, a clear demarcation between buccal cavity and pharynx occurs in *L. dero*. as there is present a prominent constriction between the two structures. Such a constriction has also been reported to occur between buccal cavity and pharynx in *Labeo horie* (Girgis, 1952).

L. dero is a herbivorous and bottom-feeding fish. The same is confirmed by the arrangement of gill-rakers which are large, hair like, compactly arranged processes and constitute an efficient sieve-like apparatus. Invariably, modified settiform gill-rakers are reported to occur in fishes which are plankton-feeders (Swarup, 1959). Such gill-rakers have also been described by Imms (1904) in *Polydon* and Seitz (1937) in *Helostoma temmincki*. While comparing the carnivorous *Gadus macrocephalus* and plankton-feeder, *Theragra chalcogramma*, Suyehiro (1940) has provided further evidence that the latter has fine gill-rakers which can easily retain food. Al-Hussaini (1945 to 1947 and 1949) has shown that different fishes with different feeding habits, namely, coral-feeders, *Scarus sordidus*, the bottom-feeder, *Mulloides auriflamma* and plankton-feeder, *Antherina forskeli*, possess variously modified gill-rakers, but in the first two fishes the chief function of gill-rakers is to protect the gill-filaments from the ill effects of silt-material, whereas in Antherina, there are primarily employed to strain food from the water.

The selection of food for a bottom-feeder is rather intriguing in the first instance the food particles which may be burried in the mud are selected with the help of barbels. In case of *L. dero*, the barbels are only two in number and reduced in size. They help but little in the selection of food. Lips may also help in the selection of food. As a matter of fact actual selection of food in *L. dero* takes place in the anterior pharynx, where numerous hair-like flexible papillae are present which are richly supplied with gustatory sense organs.

Therefore, the gill-rakers primarily function as a sieve and thus protect the delicate gill filaments from the ill-effects of silt-material.

Majumdar and Saxena (1961) are of the opinion that anterior pharynx is concerned chiefly with respiration. But the histological details do not support this view fully, at least in *L. dero*. The occurrence of numerous gustatory organs or taste buds in the roof of anterior pharynx and also the occurrence of numerous hair-like papillae equipped with taste buds go against the findings of Majumdar and Saxena (1961). Therefore, it supports the views of the present authors that the anterior pharynx serves a digestive function and similar are the observations of Girgis (1952) in *L. horie*.

The floor of the anterior pharynx has the same histological structure as that of the roof except for a couple of differences. Firstly, the taste buds are fewer; hardly one taste bud is visible in a single crest. Secondly, the basement membrane is comparatively thicker.

Discussion

Labeo dero is essentially a hill-stream fish. The lips which bound the mouth are highly fleshy and help the fish in the mechanism of adhesion which is particularly required in the hill-stream fishes. Fleshy lips have also been described to occur in another hill-stream fish, *Tor putitora* (Lal, 1962).

Al-Hussaini (1949) reported the occurrance of a maxillary valve in *Ratulus*, *Gobio* and *Cyprinus* which in his opinion operates against the floor of the mouth. Kapoor (1953) reports the occurrence of two such structures in *Wallagonaia attu* and calls them as the velar membranes. A velar membrane has also been reported to occur in *Tor putitora* (Lal, 1962). In *L. dero* the present authors have also observed a crescentic fold-like structure hanging from the roof of the buccal cavity at the anterior end It is well-developed and closes the mouth opening completely by operating against the floor of the buccal cavity. The presence of a well-developed maxillary valve points out to the fact that whatever food is grasped by the fish should not incur the risk of being washed away from the buccal cavity with the fast currents of hill-streams.

It has been reported by previous workers that the anterior part of the floor of the buccal cavity becomes thickened to form a sort of tongue. In cyprinids, such a structure is reported to occur in a rudimentary state is *Campostoma anomalum* (Curry, 1939). A similar structure occurs in *Tor putitora* (Lal, 1962). However, tongue is conspicuously absent in *Labeo horie* (Girgis, 1952). Same is confirmed in *L. dero*.

The histological structure of the buccal cavity is also interesting. Well-developed gustatory receptor organs accompained with numerous mucus-secreting cells occur in the mucosal coat of the buccal cavity of *L. dero*. The function of the gustatory receptor organs has been emphasised by various workers (Al-Hussaini, 1949; Kapoor, 1953 and 1954; Swarup, 1959; and Brown, 1957) to be the selection of food. The mucus secreted by the mucous cells helps in forming a lubricating substance which when mixed with the food helps the latter to slip in the pharynx easily.

In the roof of the buccal cavity of *L. dero* there occurs a special structure termed as the lamellar organ of the palate. Such a structure has also been repoited by Girgis (1952) in *L. horie*, Majumdar (1951) in *Cirrhina mrigala* and Majumdar and Saxena (1961) in *L. dero*. It is noteworthy that the histological details observed by Majumdar and Saxena (1961) in the palatal organ of *L. dero* are to much extent different from those observed by the present authors. Firstly, they do not record the presence of gustatory organs in the mucosa of the palatal organ. In the present material gustatory receptor organs occur in plenty; one fold has at least one gustatory organ. Secondly, Majumdar and Saxena (1961) have failed to observe stratum compactum which lies below the basement membrane. They state, "the basement membrane below the epithelial layer is very thin. The underlying sub-mucosa forms the base and core of these plates". In contrast to their observations, in our material stratum compactum is well-developed and takes part in the formation of the lamina propria.

Posterior pharynx is concerned with the mastication of food material (Girgis, 1952 ; Al-Hussaini, 1949 ; and Chu, 1935). And therefore, in *L. dero* it is provided with two structures—a horny pad in the roof and pharyngeal teeth at the floor. The pharyngeal teeth, besides being broad at the tips, are closely set. Thus an elaborate arrangement for the crushing of the food is made. Such a condition has also been reported by Sarbahi in *L. rohita* (1939).

Chu (1935), who carried out a detailed and comprehensive study of pharyngeal arches and teeth of certain cyprinid fishes, distinguished three principal categories of teeth in Cyprinidae, *viz.*, (1) compressed, (2) depressed, and (3) conical. The homodont teeth of *L. dero* appear to be of the compressed type according to the classification of Chu (1935).

Summary

1. *Labeo dero* is herbivorous, bottom-feeding fish in which the mouth is crescentic and greatly protrusible. Lips are highly fleshy and help in adhesion. Tongue is conspicously absent. The maxillary valve is present.

2. Buccal cavity is clearly demarcated from the pharynx. Numerous folds are present in the buccal cavity as well as in the pharynx.

3. A lamellar organ of the palate is present in the posterior half of the roof of the buccal cavity Anterior pharynx is furnished with numerous papillae. Gill-rakers are long, hairy and compactly arranged.

4. Posterior pharynx comprises of a horny pad in the roof and a set of pharyngeal teeth at the floor. Teeth are of the compressed type and their shape and arrangement are in harmony with the feeding habits of the fish.

5. Histological details of buccal cavity present the usual structure. However, the lamellar organ of the palate has numerous mucous cells and a distinct stratum compactum is present. Taste buds are also observed.

6. Anterior pharynx has numerous taste buds and hairy papillae. The hairy papillae are equipped with numerous taste buds.

7. The present authors do not agree with the views of Majumdar and Saxena (1961) that the anterior pharynx is respiratory in nature. In our opinion, the anterior pharynx plays an important part in the selection of food as is evidenced by the presence of numerous hair-like papillae.

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THE DIGESTIVE SYSTEM OF SOME BRITISH AMPHIPODS—III. THE ALIMENTARY CANAL

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Hitherto, little attempt has been made to find out if any correlation exists between habitats, feeding habits, feeding appendages and alimentary canals of amphipods. In fact no detailed description of the alimentary canal of any amphipod is available. In this work 18 species of amphipods with diverse habitats and feeding habits have been described. Forms like *Orchestia* and *Gammarus* are macrophagous, others like *Haustorius* and *Bathyporeia* are microphagous, *Chelura* is xylophagous, *Hyperia* lives with in the body of medusae while *Cyamus* is an ectoparasite on whales.

The alimentary canal of an amphipod consists of foregut, midgut and hindgut. The foregut includes the mouth, oesophagus and stomach; the stomach is divisible into anterior cardiac and posterior pyloric regions. The cardiac stomach, with its internal cuticular wall produced into a series of chitinous plates or ridges armed with teeth, hairs, spines or hooks, acts as an auxillary masticatory organ. The inner wall of the pyloric chamber is produced into a large number of long spines and forms an effective filter apparatus. The midgut in most of these amphipods, gives out three sets of caeca namely anterior dorsal, posterior dorsal and ventral hepato-pancreas; the last secrete the digestive enzymes. The small, rectum opens to the exterior by a slit-like dorsal or ventral anus.

In this present paper, the alimentary canals of nine amphipods have been described in detail; the alimentary canal of remaining 9 species will be dealt in a subsequent paper.

Historical

Bate and Westwood (1856), Sars (1895) and Chevreux and Fage (1925) described the distribution and external characters of the amphipods. The habit and feeding of some of the animals have been studied by more recent authors. Watkin (1938 and 1939) studied the burrowing habits of *Bathyporeia*. The feeding mechanism of *Haustorius* has been described by Dennell (1933) and Crawford (1937) while Watkin (1940) described those of *Urothoe*. Calman (1921) and Barnard (1951) studied the habits of *Chelura*. *Caprella* has been described by Harrison (1940). Hart (1930) gave a detailed account of the swimming behavior of *Corophium*. Hollowday (1948) studied that of *Hyperia* while Iwasa (1934) described the external characters of *Cyamus*. The only references on the alimentary canal of any amphipod are those of Ide (1892) and Cussan (1904) who briefly dealt the alimentary canal of *Gammarus*. Huxley (1880), Gelderd (1907), Reddi (1938) and others have described the armature of the foregut in some of the Crustacea.

Materials and Methods

Orchestia, *Talitrus*, *Marinogammarus*, *Corophium* and *Caprella* were collected at Whitstable. *Haustorius*, *Urothoe*, *Bathyporeia*, *Jassa*, *Gammarus chevreuxi*, *Melita* and

Isaea were collected at Plymouth ; *Chelura, Dexamine, Orchomenella* and *Hyperia* were procured in the preserved condition from Marine Biological Station, Plymouth. Finally, a few specimens of *Cyamus* were supplied by the Natural History Museum, London.

The gross anatomy of the alimentary canal of the different animals was studied both by dissections and by making permanent stained preparations of the whole animals. For detailed study of the internal structure of the alimentary canal, horizontal as well as transeverse sections of the alimentary canal were studied. Reconstruction drawings of the entire animal with the replacement of the alimentary canal, were also drawn.

Morphology of the Alimentary Canal

Family Talitridae

The family includes the sand hoppers, commonly found along the line of decaying weeds at high water mark of the sea shore.

Orchestia gammarella Pallas is common on British shores at high water level under weeds and stones ; it may, however, occur ·inland away from the sea. A full grown specimen of *Orchestia* is about 18 mm. long, reddish brown in colour. It is omnivorous in habit and eats · very large amounts of food daily, feeding indiscriminately on whatever comes its way, though it does not attack living animals.

The mouth of *Orchestia* is ventral in position; it leads into a narrow oesophagus which in its turn opens into the ventral part of the cardiac stomach. In a full grown specimen of *Orchestia*, the stomach as a whole is 1·3 mm. long of which the cardiac stomach is 0·8 mm. long while the pyloric stomach is only 0·5 mm. long. The inner cuticular lining of the cardiac stomach is raised into paired dorso-lateral, lateral and ventro-lateral ridges.

The dorso-lateral ridges (Fig. 1, I, D.L.), about 0·15 mm. wide, arise from the anterior most part of the stomach and extend backwards into the midgut upto the beginning of fourth thoracic segment. These ridges bear a few long spines. Paired lateral ridges (L.L.) are only 0·5 mm. long and extend only a short distance along the cardiac stomach ; each ridge has a few strong teeth-like structures directed upwards. A pair of small oesophageal ridges (L.S. ANT. REG., OE A.) are also present at the junction of the oesophagous and stomach and bear a few fine bristles, distally.

A pair of ventro-lateral ridges (V.L.), initially only 0·25 mm. wide, extend as very wide ridges along the pyloric stomach and finally end in the midgut (Fig. 1, VI, V.L.). In the region of the cardiac stomach, the ventro-lateral ridges extend deep into the lumen as lamelliform structures, overlapping each other. Thus the cardiac chamber in this region is divisible into three parts, a small dorsal chamber separated by dorso-lateral ridges, a large middle chamber and a small ventral chamber separated by ventro-lateral ridges (Fig. 1, II).

Towards the beginning of the second thoracic segment, the cardiac stomach passes into the pyloric region. The pyloric chamber is divisible into an upper dorsal and the lower ventral part. The upper chamber is a cylindrical passage leading directly from the cardiac stomach into the midgut. The lower chamber is much complicated ; from its floor arises the mid ventral piece or pyloric piece (Fig. 1, III, M.V.P.) which extends a long way upwards where it terminates as a conical projection. On either side of this piece are present two protuberances,

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each with a long spine (Fig. 1, III). The ventral chamber of the pyloric stomach is thus divided into two pyloric grooves. The ventro-lateral ridges become very wide—their distal extremities facing the distal end of the pyloric piece—allow only a very narrow passage between the upper and the lower chamber. The sides of the ventro-lateral ridges are produced into fine bristles so that the pyloric stomach forms an effective filter apparatus.

Towards the end of the second thoracic segment, the pyloric stomach opens into the midgut. The midgut is drawn out anteriorly, into a median dorsal caecum (Fig. IV, D.CA.) which extends forwards above the stomach to end blindly almost opposite the mouth. From the antero-ventral side of the midgut arise two lateral pouches (Fig. 1, IV, V.CA.) which extend forwards upto the second thoracic segment and then turn backwards. Finally, these ventral caeca divide into two pairs (Fig. 2, VI, V.CA.) which extend upto the end of the fourth abdominal segment. From the middle portion of the mid-dorsal wall of the midgut arises a posterior dorsal caecum which immediately divides into a pair of small caeca (Fig. 2, VII, P D.CA), extending upto the fourth abdominal segment. Another pair of small posterior dorsal caeca also arise from the posterior wall of the midgut.

The rectum of *Orchestia* forms a small narrow portion of the alimentary canal; its internal cuticular lining is much complicated. In the region of the third abdominal segment, a well developed typhlosole-like projection hangs down from its dorsal wall; slightly latter, another projection arises from the ventral margin of the rectum. Posteriorly, the inner wall of the rectum bears a large number of small knobs (Fig. 2, VIII) which are produced into small spines projecting into the lumen. The internal cuticular lining becomes much thickened and is produced into a large number of folds, so that the lumen is reduced (Fig. 2, XII) in order to force out the faeces through the small ventral anus (Fig. 2, XIII, AN.).

The alimentary canal of *Talitrus saltator* Montagu, another example studied from the family Talitridae does not show any marked differences from that of *Orchestia* and does not need a separate description.

Family Haustoriidae

The family Haustoriidae is represented in the coastal waters of Great Britain by three genera, *Bathyporeia*, *Haustorius* and *Urothoe*, all of which are characterised by their habit of burrowing into sand.

Bathyporeia pilosa Lindstrom is found abundantly in the inter-tidal sands around the British shores extending into comparatively deep water.

According to Hunt (1925), *Bathyporeia* is a deposit feeder selecting and picking out organic material from the substratum. During burrowing, it feeds by clearing the surfaces of the sand particles.

The ventral mouth of *Bathyporeia* opens into narrow oesophagus which is lined internally by thickly chitinous layer. The oesophagus at its opening into the stomach is provided with a few upwardly directed spines.

The cardiac stomach is about 0·2 mm. long and extends upto the first thoracic segment. In its anterior region, its roof hangs (Fig. 3, I) so that the lumen of the stomach is much reduced. A pair of dorso-lateral ridges (D.L.), about 40μ wide arise from the middle of the cardiac stomach and extend backwards along the

pyloric stomach into the midgut where they end in the second thoracic segment. They are provided with a few long spines. The lateral ridges of *Bathyporeia* (Fig. 3, IV, L.L.) are well developed being about 70µ long and 50µ wide ; each bears, anteriorly, a pair of large serrated teeth. Further back, they develop six well developed teeth arranged in a row and serrated on their upper edge. The posterior part of the ridge is without any teeth. In the anterior region, the floor of the cardiac stomach is also raised into a chitinous upgrowth (Fig. 3, VII, V.A.), bearing a few upwardly directed small spines. The sides of the stomach are also raised into well developed ridges which are produced into long spines. Thus we find that the inner wall of the anterior region of the cardiac stomach is thickly chitinous and is produced into a large number of teeth, spines and bristles. In the middle region, where the lateral ridges are lost, the internal lining of the cardiac stomach is thikly chitinous and is produced into a large number of small spines. The floor is also produced into a median long upgrowth and two lateral pad-like structures situated on either side of the median upgrowth—all provided with small spines (Fig. 4, VI, A.).

In the posterior part of the cardiac stomach, paired ventro-lateral ridges (Fig. 3, VI, V.L.) appear as wide outgrowths, each bearing about a dozen long spines directed upwards and inwards. Posteriorly, the ventro lateral ridges lose their spines and extend into the lumen as lamelliform structures and form a sort of septum between the middle and ventral region of the stomach (Fig. 3, VII). The distal extremities of these ridges are thickly chitinous.

Towards the middle of the first thoracic segment, the cardiac stomach opens into the pyloric chamber. The inner wall of the pyloric stomach is also thickly chitinous. The mid-ventral piece, only 30µ high anteriorly becomes as deep as 0·115 mm. in its middle region (Fig. 3, IX, M.V.P.). Three knob-like protuberances on each side of the pyloric piece bear long spines ; the inner margin of each ventro-lateral ridge facing the pyloric piece is produced into a large number of small spines and a single large spine (Fig. 3, VIII), corresponding in position to the top of the mid-ventral piece. Thus the pyloric stomach forms an effective filter apparatus. Posteriorly, the mid-ventral piece broadens at the expense of the cavity of the stomach ; its blunt dorsal end bears a few spines. The protuberances of the two sides have a large number of small spines arranged like the teeth of a comb (Fig. 3, IX).

The midgut of *Bathyporeia*, at its anterior and dorsal margin is prolonged into a narrow tubular dorsal caecum which runs forwards above the stomach and ends blindly towards the beginning of the first thoracic segment. Paired ventral caeca are given out from the anterio-ventral margin of the midgut and run backwards as wide tubes (Fig. 3, IX, V.CA.) upto fourth abdominal segment where they terminate blindly. A very small caecal ridge (Fig. 4, XI, C.A.) is present at the ventral margin of the midgut where ventral caeca arise. In the mid-body region, the midgut is exceedingly norrow being only 1/20th. of the body size. (Fig. 4, XIII) while the ventral caeca are much wider.

Towards the middle of the fifth abdominal segment, a pair of posterior dorsal caeca (Fig. 4, XIV, P.D.CA.) extend upto the beginning of the sixth abdominal segment. Posteriorly, the midgut becomes wider and its inner wall is greatly thickened.

The midgut in the region of the fifth abdominal segment, opens into short rectum which opens to the exterior through a narrow anus (Fig. 4, XVIII, AN.).

Haustorius arenarius Slabber has been recorded as an inhabitant of the intertidal and shallow water sands of the British coast. Its characterstic shape is

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regarded as an adaptation to its burrowing habit. Sars (1895), Stebbing (1906) etc. described only the female of *Haustorius*. Watkin (1941), however, recorded the male which does not show any apparent external differences from the female. Dennell (1933) has described the feeding mechanism of the animal.

A full grown specimen of *Haustorius* is about 8 mm. long with short and robust body.

The alimentary canal of *Haustorius*, though generally similar to that of *Bathyporeia* but the critical study shows a few differences especially in the presence of a large number of chitinous ridges beset with spines and hooks.

The cardiac stomach is about 0·24 mm. long and 0·14 mm. wide. The anterior continuation of the stomach beyond the mouth has a median ventral ridge beset with a few spines (Fig. 5, I). From its floor, arises a chitinous process—48μ thick and 30μ long also provided with spines (Fig. 5, II, D.A.). Paired oesophageal ridges (OE. A.) are also present at the junction of the oesophagus and stomach. The lateral ridges in *Haustorius* are exceptionally well developed (Fig. 5, III, L.L.) being adout 40μ wide. Anteriorly, each is provided with a sparse coating of fine bristles. Posteriorly, the ridges are provided on the ventro-lateral margins with a single large tooth, serrated along its upper edge, and a few large simple teeth, all of which are directed upwards and inwards.

In the same region, paired dorso-lateral and ventro-lateral ridges also arise which are beset with long spines. From the floor of the stomach arises the ventral ridge (Fig. 5, IV, V.A.) which bears a few spines distally. The lateral wall of the stomach in between the dorso-lateral and ventro-lateral ridges is also thickly chitinous.

In the region of the first thoracic segment, the cardiac stomach passes into the pyloric stomach. The pyloric piece, only 20μ high anteriorly (Fig. 5, VII, M.V.P.) becomes 96μ high in the middle; its sides, in this region, being produced into three well developed spined protuberances (Fig. 6, VI, M.V.P.), so as to form two pocket-like structures on each side. The ventro-lateral ridges become very wide and extend dorsally to meet the dorso-laterals of their own sides. The inner and distal edges of the ventro-lateral ridges, beset with fine bristles, are directed upwards and correspond with the apex of the pyloric piece so as to allow a very narrow sieve-like passage between the upper and the lower chamber of the pyloric stomach (Fig. 6, VI).

The pyloric region, in the middle of the second thoracic segment, opens into the midgut. The dorso-lateral and ventro-lateral ridges of the stomach are continued into the lumen of the midgut upto fourth thoracic segment (Fig. 6, X, ST.).

The anterior dorsal caecum, soon after its origin, divides into paired structures extending forwards on either side of the stomach upto the first thoracic segment (Fig. 5, VIII, D.CA.). Paired ventral caeca also run forward for a short distance (V.CA.) : their backward extensions, in the region of the third thoracic segment, divide to form two pairs (Fig. 6, XI. V.CA.) which end blindly towards the middle of the fourth abdominal segment.

A pair of posterior dorsal caeca (Fig. 6, XII, P.D.CA.), coiled in a complicated manner to form a double loop, arise from the midgut just before the beginning of the fourth abdominal segment (L.S. POST. REG.).

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The inner chitinous wall of the rectum is thick and folded. Posteriorly, it becomes laterally compressed and opens to the exterior by dorsal anus (Fig. 6, XIX, AN.).

Urothoe marinus Bate is commonly found in the inter-tidal and shallow water sands, often in the same habitat as *Bathyporeia* and *Haustorius*. Crawford (1937) and Watkin (1940) have described the burrowing habit of the genus.

The foregut of *Urothoe* shows certain characterstic differences with those of *Bathyporeia* and *Haustorius*. Its internal wall is comparatively smooth and less chitinous. The passage of mouth into oesophagus is guarded with an incomplete chitinous septum which is continued into the cardiac stomach. This sort of septum is peculiar to *Urothoe* alone. Posteriorly, the septum divides into a small dorsal portion (Fig. 7, I & II)—which is soon lost ; the ventral portion, with its fellow of the opposite side forms paired ventro-lateral ridges. The lateral ridges are not well developed (Fig. 7, IV, L.L.) and are not thickly chitinous. The narrow apex of each ridge bears a single large serrated tooth, directed upwards and inwards. A small ventral ridge with a few distally placed spines (Fig. 7, V, V.A.) is also present. The cardiac chamber in this region is very wide and is almost without any ridges or spines (Fig. 7, V).

Paired dorso-lateral ridges (Fig. 8, VI, D.L.) arise from the middle of the cardiac stomach and extend backwards a long way into the midgut.

The cardiac stomach in the region of the second thoracic segment passes into the pyloric stomach. The ventro-lateral ridges become very wide (125μ) and lie opposite to the mid-ventral piece, which also extends a long way upwards and thus forms an effective filter apparatus. However, the pyloric piece in *Urothoe* is not produced into protuberances on the two sides, as in other amphipods. The sides of the ventro-lateral ridges and the wall of the stomach between the ventro-lateral and dorso-lateral ridges are thickly chitinous (Fig. 7, VIII).

It seems that in *Urothoe*, paired ventral caeca, instead of arising from the midgut, originate from the ventral wall of the pyloric stomach (Fig. 8, X, V.CA.) and extend a short way forwards as wide tubes. Their backward extensions continue posteriorly upto the middle of the fifth abdominal segment. A small caecal ridge (C.A.) also arises from this part of the stomach.

The midgut, anteriorly, gives out a single median dorsal caecum (Fig. 8, XI, D.CA.) In the region of the fifth abdominal segment, posterior dorsal caeca arise as a pair of long tubes, coiled in the form of a Z (Fig. 9, L.S. POST. REG.).

The rectum is a small wide tube, opening to the exterior through a dorsal anus (Fig. 9, XIX, AN.).

Family Dexaminidae

Dexamine spinosa Montagu is about 15 mm. long and is found in moderate depths, ranging from 6 to 30 fathoms, among algae.

The internal wall of the cardiac stomach is thickly chitinous and is produced into a large number of spines. The anterior portion of the cardiac chamber is very narrow and bears a pair of dorso lateral ridges and has thickly chitinous roof (Fig. 10, II). The dorso-lateral ridges are very small and bear only one or two long spines. However, these ridges are followed by another pair of long dorso-lateral ridges (L.S. ANT. REG.), which extend a long way into the midgut. Oesophageal ridges (Fig. 10, III, OE.A.), bearing a few fine bristles, are also present at the junction of oesophagus and stomach.

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Paired lateral ridges of *Dexamine spinosa* bear a few fine bristles and a single large tooth, directed upwards and serrated on its outer margin (Fig. 10, III, L.L.).

Posteriorly, where the lateral ridges are lost, the lateral and ventro-lateral wall of the stomach gets greatly thickened and is produced into a large number of strong upwardly directed spines (Fig. 10, V). A well developed ventral ridge, bearing fine spines distally, is also present in the anterior part of the cardiac stomach. The ventro-lateral ridges, in the region of the cardiac stomach, are very wide carrying small spines on the lateral and upper margins. Thus we find that the cardiac stomach of *Dexamine* is strongly built with a large number of ridges ; its wall being produced into a large number of strong spines.

Towards the middle of the first thoracic segment, the cardiac stomach passes into the pyloric stomach. The mid-ventral piece of the pyloric stomach is well developed right from the beginning (Fig. 10, VII, M.V.P.). The outer margin of the pyloric piece gives out three protuberances on each side. The upper most protuberance, corresponding with a single knob-like structure of the ventro-lateral ridge, forms a narrow exit between the dorsal and the ventral chambers of the pyloric stomach. The ventro-lateral and dorso-lateral ridges of each side unite with each other and are furnished with a number of strong spines on their upper margins. The wall of the stomach between the ventro-lateral and dorso-lateral ridges is especially thickened and carries a large number of tooth-like structures arranged in two rows (Fig. 11, VI). Posteriorly these teeth are replaced by a few long spines.

In the region of the second thoracic segment, the pyloric stomach opens into the midgut. The anterior dorsal caecum runs forwards above the stomach (D.CA.) to end blindly opposite the mouth. Paired ventral caeca (Fig. 10, IX, V.CA.) run a short way forward ; their backward extensions soon divide into pairs of tubular ventral caeca which extend upto the middle of the third abdominal segment. The epithelial lining of the anterior part of the midgut is lined with tall vacuolated cells. In the middle region, the wall of the midgut is produced into a few villi. A pair of very small posterior dorsal caeca (Fig. 11, XII, P.D.CA.) arise from the midgut in the region of the fifth abdominal segment.

The small rectum, lined internally with thick cuticle, opens to the exterior by a small slit-like dorsal anus.

Family Isaeidae

Isaea montagui Dana is very commonly found between the mouth parts of *Maia.*

The stomach of *Isaea*, in a full grown sepeimen, is about 0·6 mm., the cardiac portion being about 0·36 mm. The stomach extends far forwards beyond the mouth as a narrow sac-like structure. Anteriorly, a pair of dorso-lateral ridges, about 0·23 mm. long and about 0·1 mm. wide and a pair of lateral ridges arise. The lateral ridges extend deep into the lumen and bear about a dozen curved spines directed upwards. The roof of the stomach hang down to form a chitinous median dorsal ridge (Fig. 12, I).

Before the anterior dorso-lateral ridges are lost, another set of dorso-lateral ridges (L.S. ANT REG., P.D.L.) arise as long structures provided with long spines and extend a long way into the midgut. Oesophageal ridges (Fig. 12, II, OE.A.) extend into the lumen as paired bulgings and bear a few fine bristles.

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ABBREVIATIONS USED

AN.—Anus ; C.A.—Caecal ridge : D.A.—Dorsal ridge ; D.CA.—Anterior dorsal caecum ; D.D.—Dorsal down growth ; D.L.—Dorso-lateral ridge ; L.L.—Lateral ridge ; MAND.—Mandible ; M.G.—Midgut : MT.—Mouth ; M.V.P.—Mid-ventral piece ; OE.— Oesophagus ; O.A. & OE.A.—Oesophageal ridge ; P.D.CA.—Posterior dorsal caecum ; P.D.L.—Posterior dorso-lateral ridge ; P.G. & PY.G—Pyloric groove ; REC.,—Rectum ; ST.—Stomach ; T.L.—Teeth on lateral side ; V.A.—Ventral ridge ; V.CA.—Ventral caeca ; V.L.—Ventro-lateral ridge ; V.U.—Ventral upgrowth.
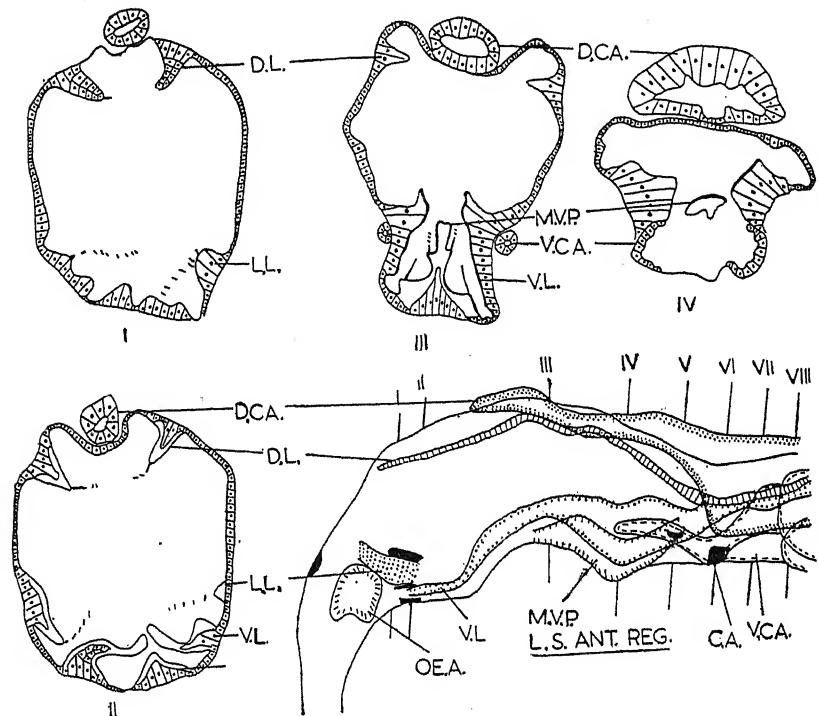
Fig. 1. *Orchestia gammarella* : L. S. ANT. REG., L. S. Anterior region of the foregut ; I to V, Transverse sections through different regions of foregut.
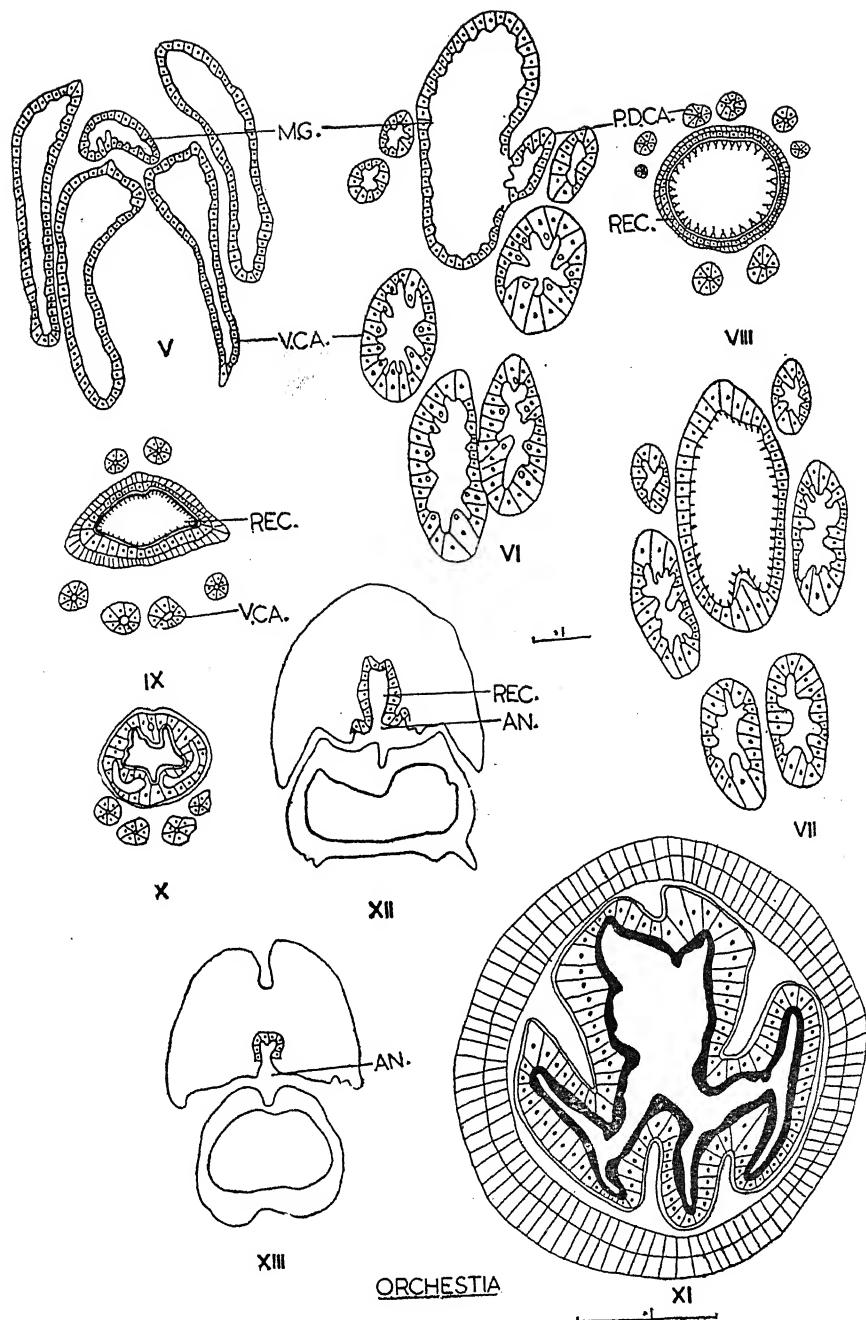
Fig. 2. *Orchestia gammarella* : V to XIII, T.S. through different regions of midgut and hindgut.
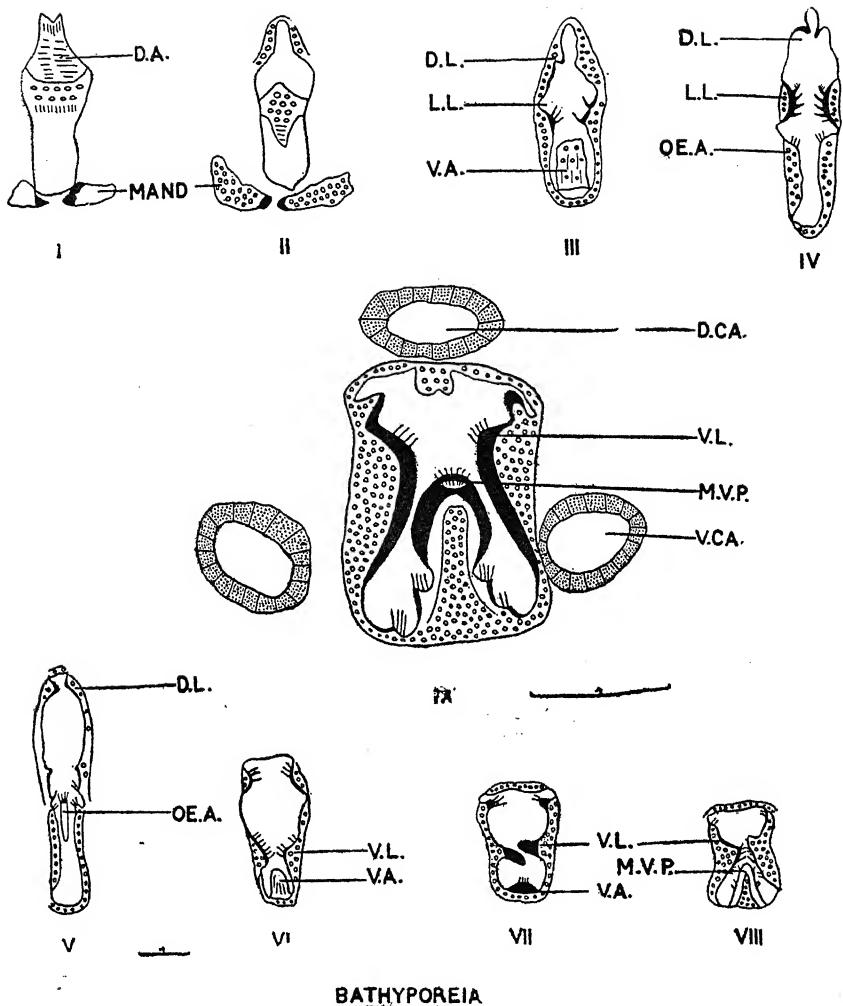
BATHYPOREIA

Fig. 3. *Bathyporeia pilosa* : I to IX, T.S. through different parts of foregut.
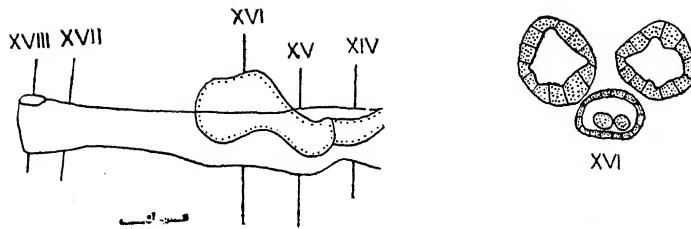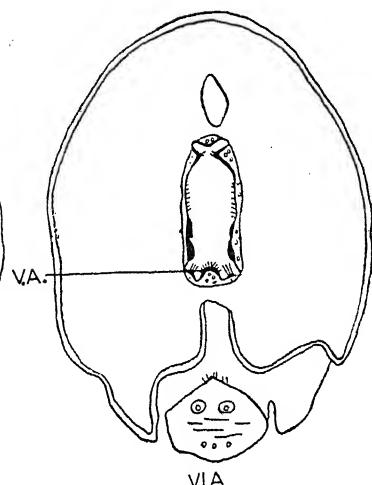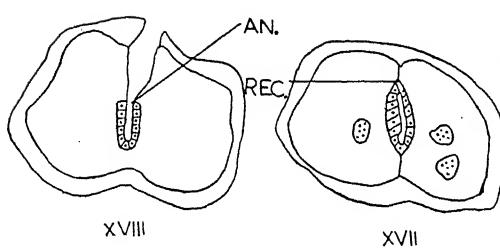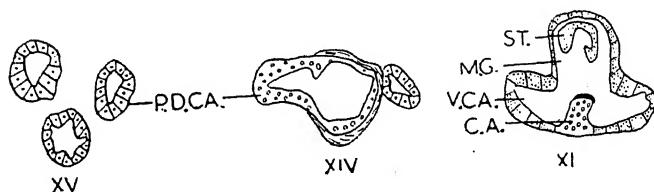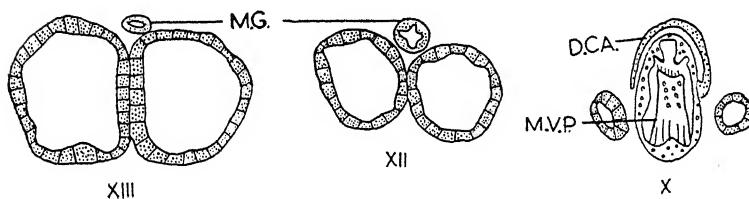
Fig. 4. *Bathyporeia pilosa* : VIA and X, T.S. through foregut ; XI to XVIII, T.S. through midgut and hindgut.
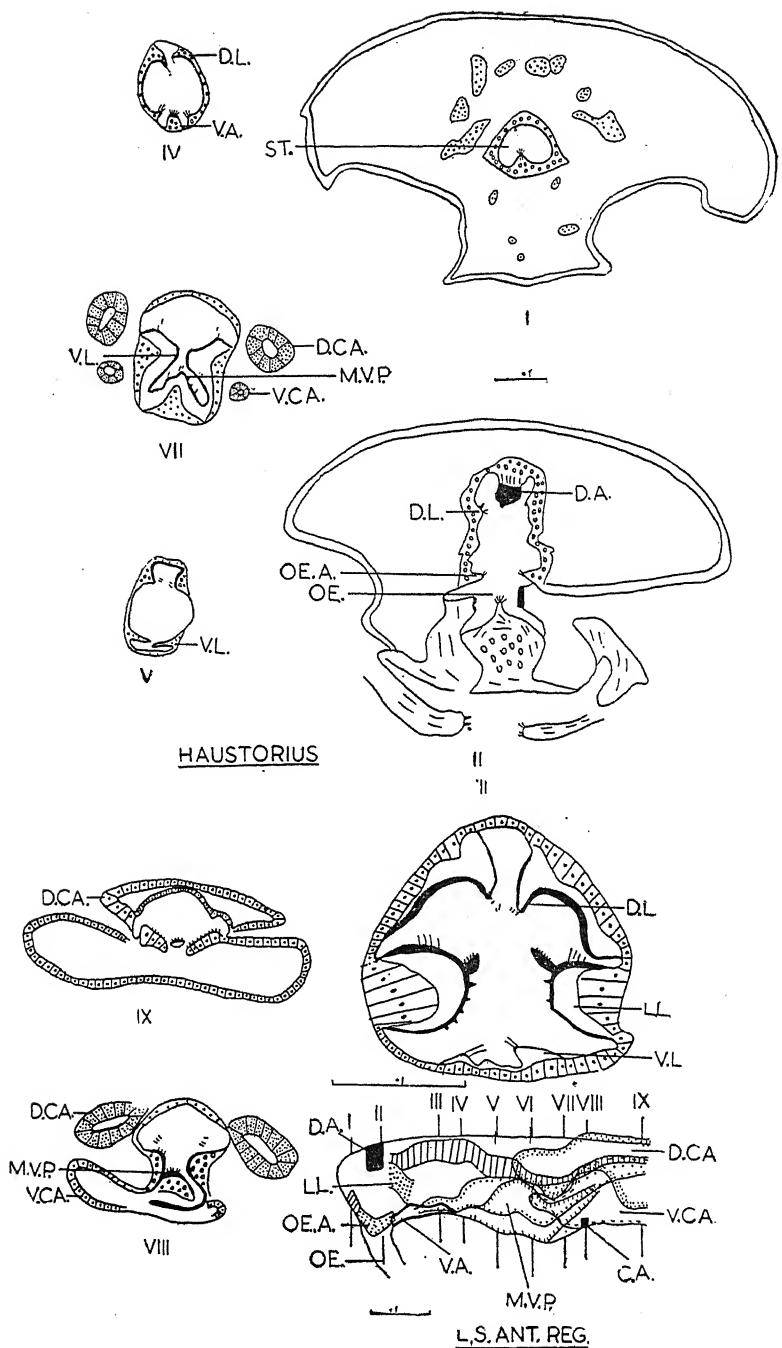
Fig. 5. *Haustorius arenarius* : L.S. ANT. REG., L.S. anterior region of foregut ; I to V and VII to IX, T.S. through different regions of foregut.
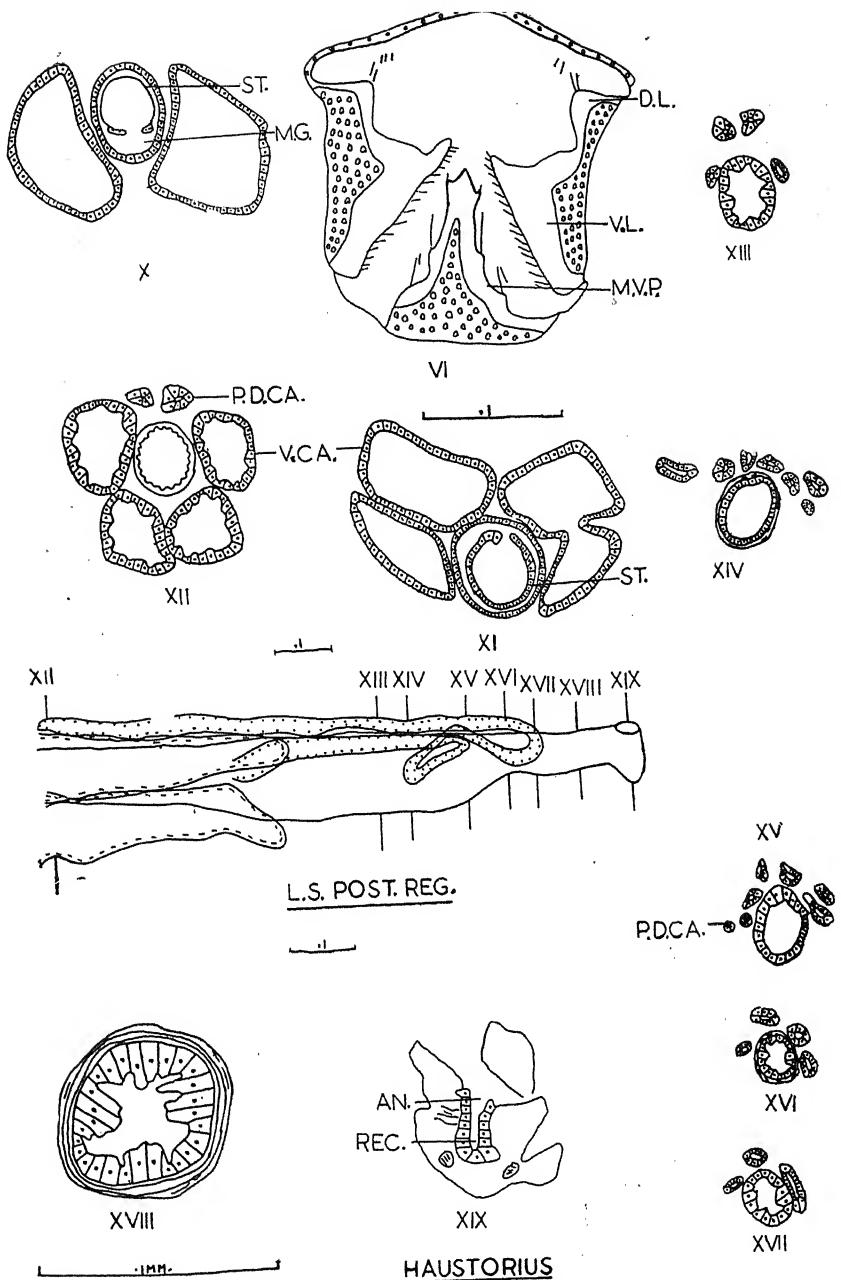
Fig. 6. *Haustorius arenarius* : L.S. POST. REG., L.S. posterior region ; VI, T.S. through pyloric stomach ; X to XIV, T.S. through midgut and hindgut.
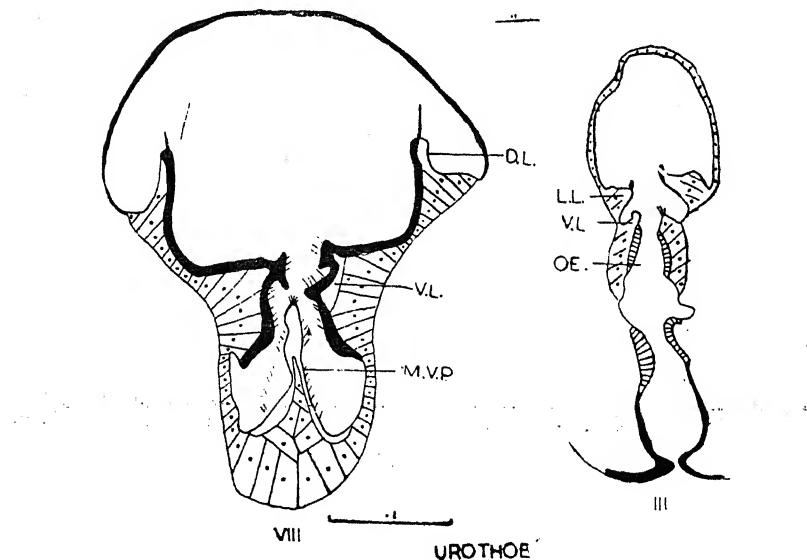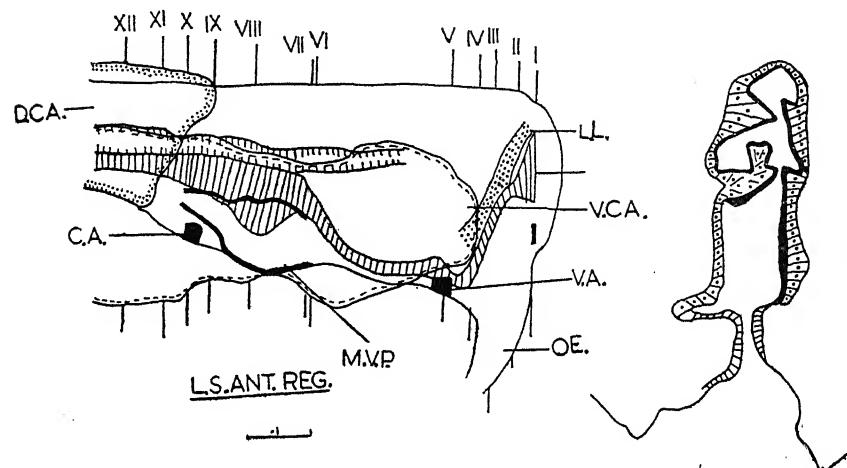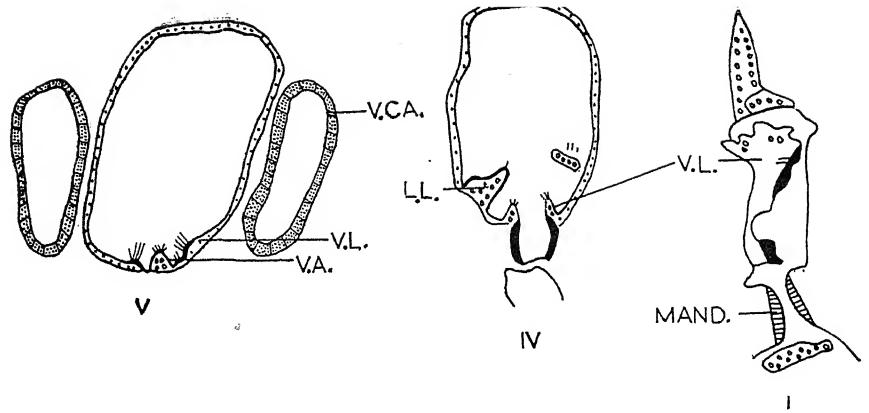
Fig. 7. *Urothoe marinus* : L.S. ANT. REG., L.S. foregut ; I to V and VIII. T.S. through foregut.
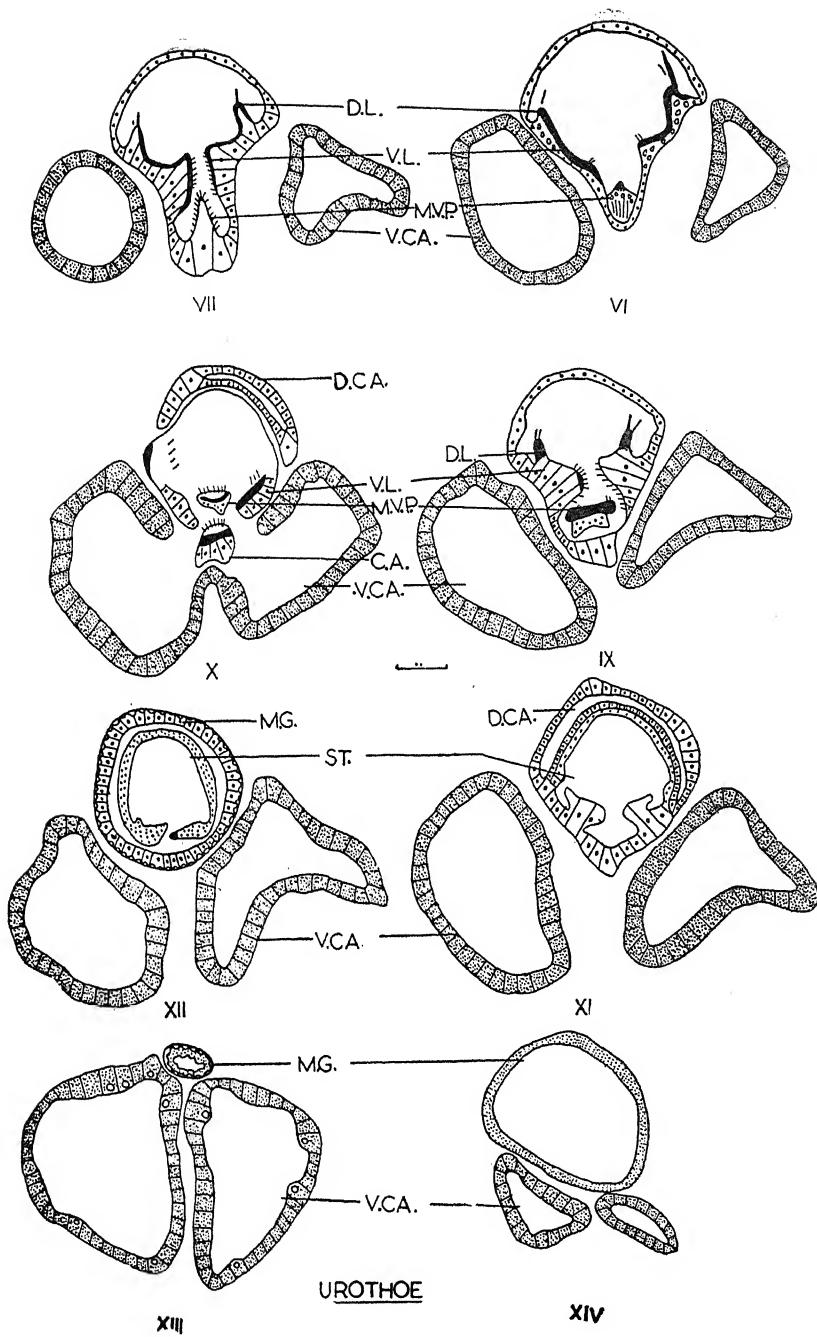
Fig. 8. *Urothoe marinus* : VI & VII, T.S. through foregut ; IX to XIV, S.T. through midgut.
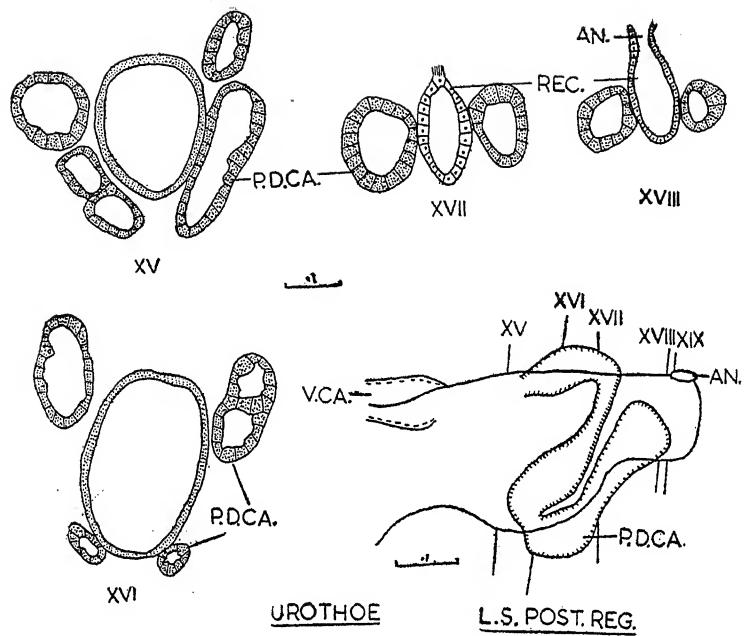
Fig. 9. *Urothoe marinus* : L.S. POST. REG., L.S. through posterior region of alimentary canal ; XV to XVIII, T.S. through midgut and hindgut.
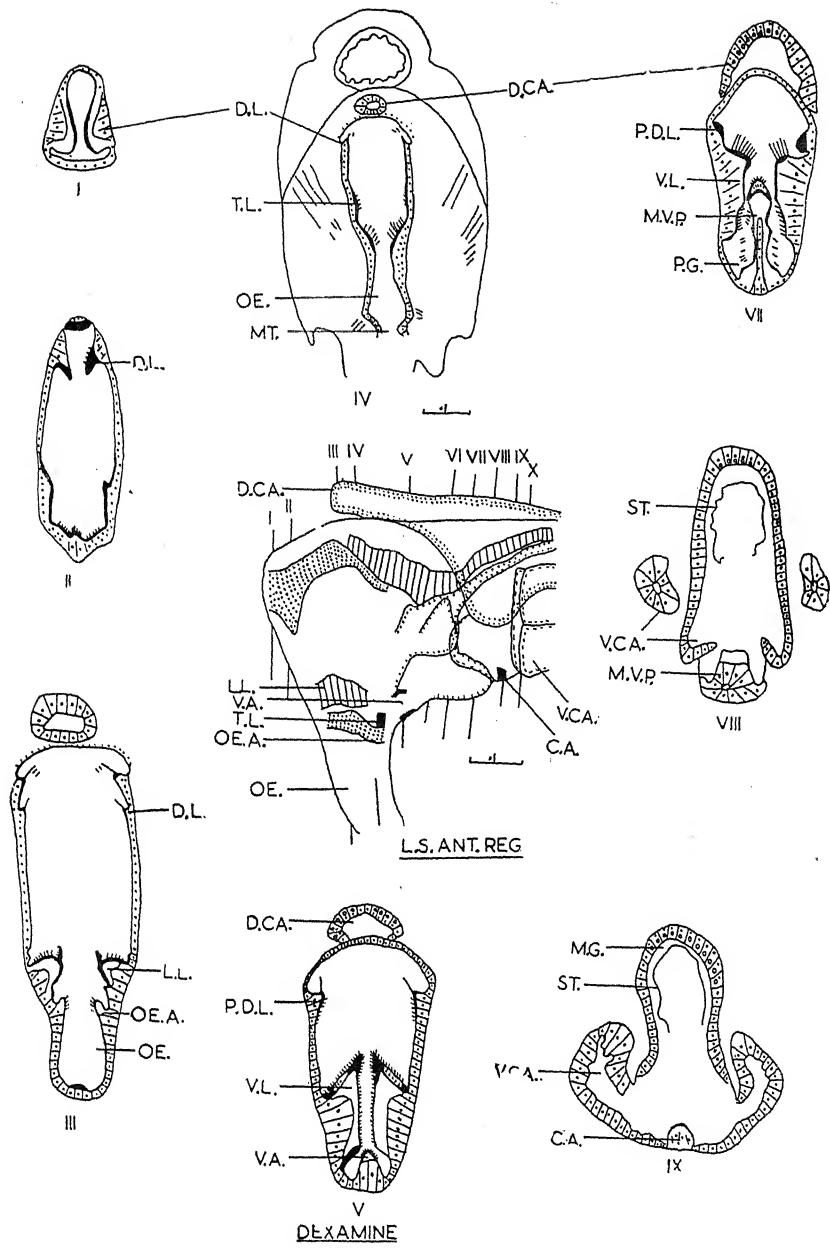
Fig. 10. *Dexamine spinosa* : L.S. ANT. REG., L.S. anterior region of gut ; I to V and VII, T.S. through different parts of foregut ; VIII & IX, T.S. through midgut.
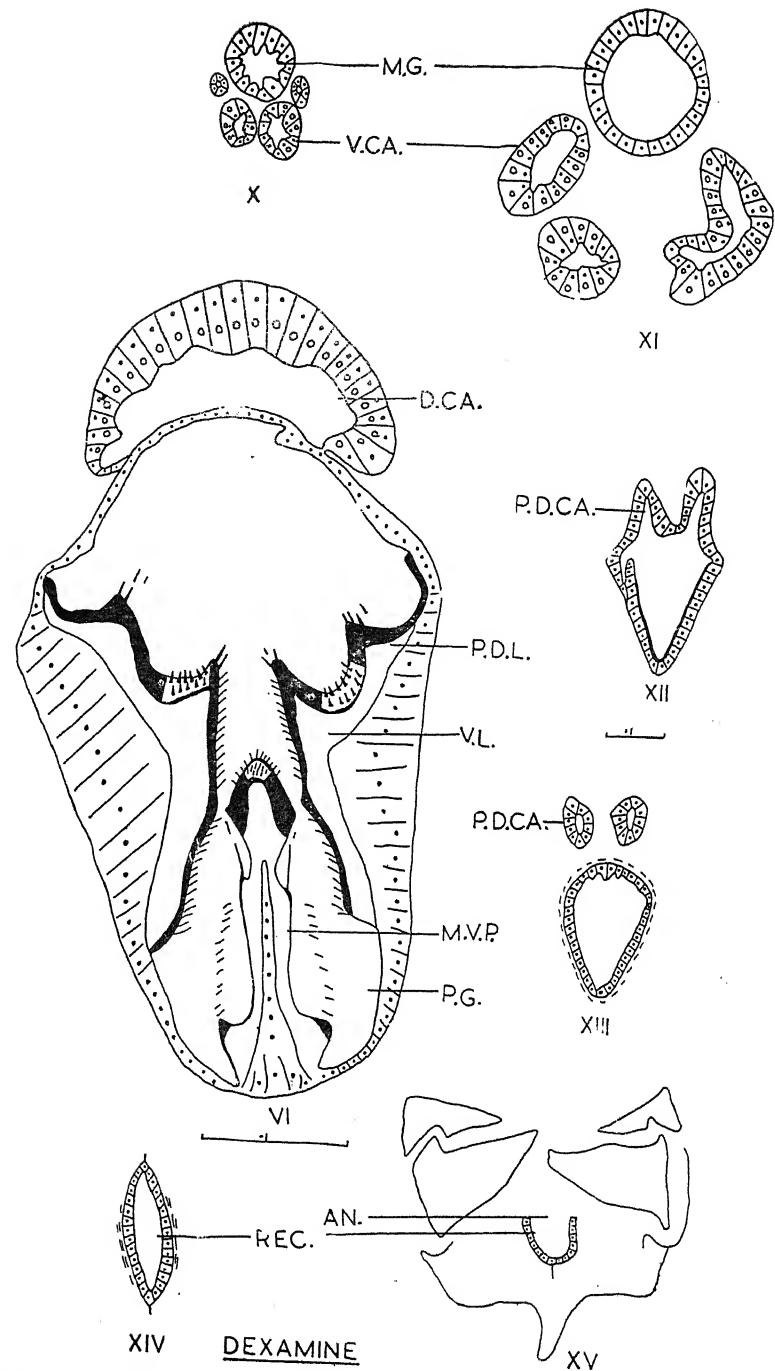
Fig. 11. *Dexamine spinosa* : VI, T.S. pyloric stomach ; X to XV, T.S. through different parts of midgut and hindgut.
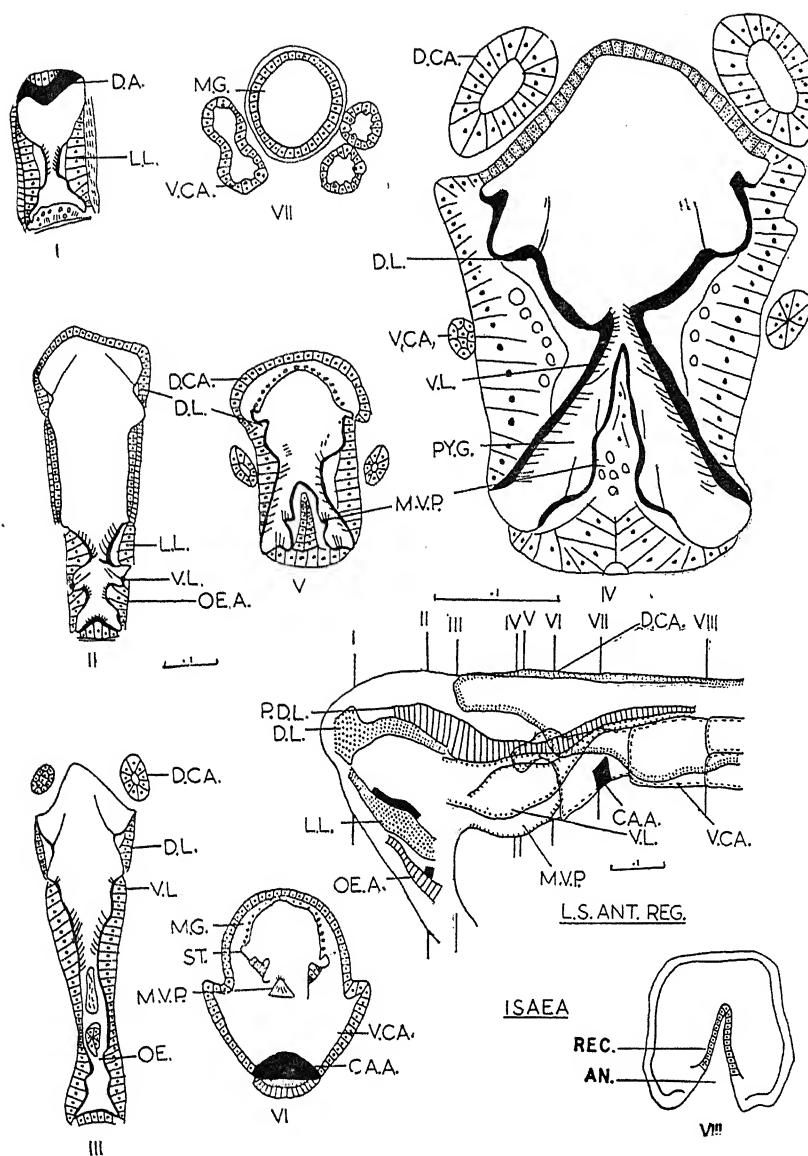
Fig. 12. *Isaea montagui* : L.S. ANT. REG., L.S. foregut ; I to V, T.S. through foregut ; VI and VII, T.S. through midgut ; VIII, T.S. through anus.
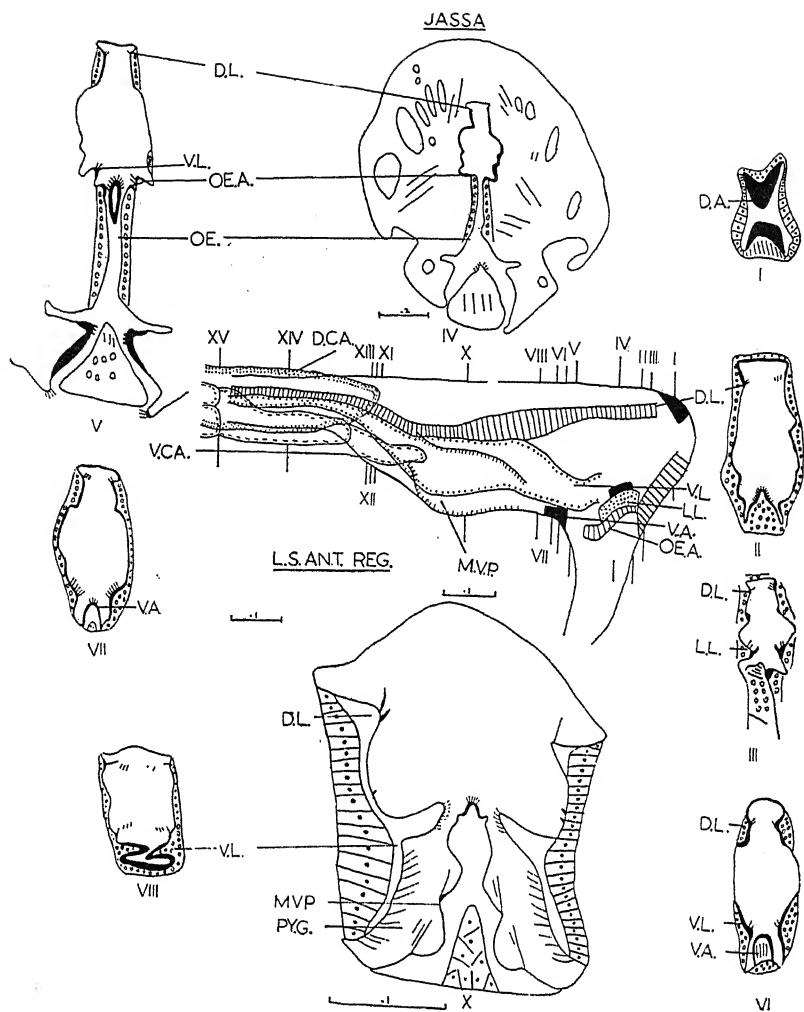
Fig. 13. *Jassa falcata* : L.S. ANT. REG., L.S. anterior region of foregut;
I to VIII and X, T.S. through different parts of foregut.
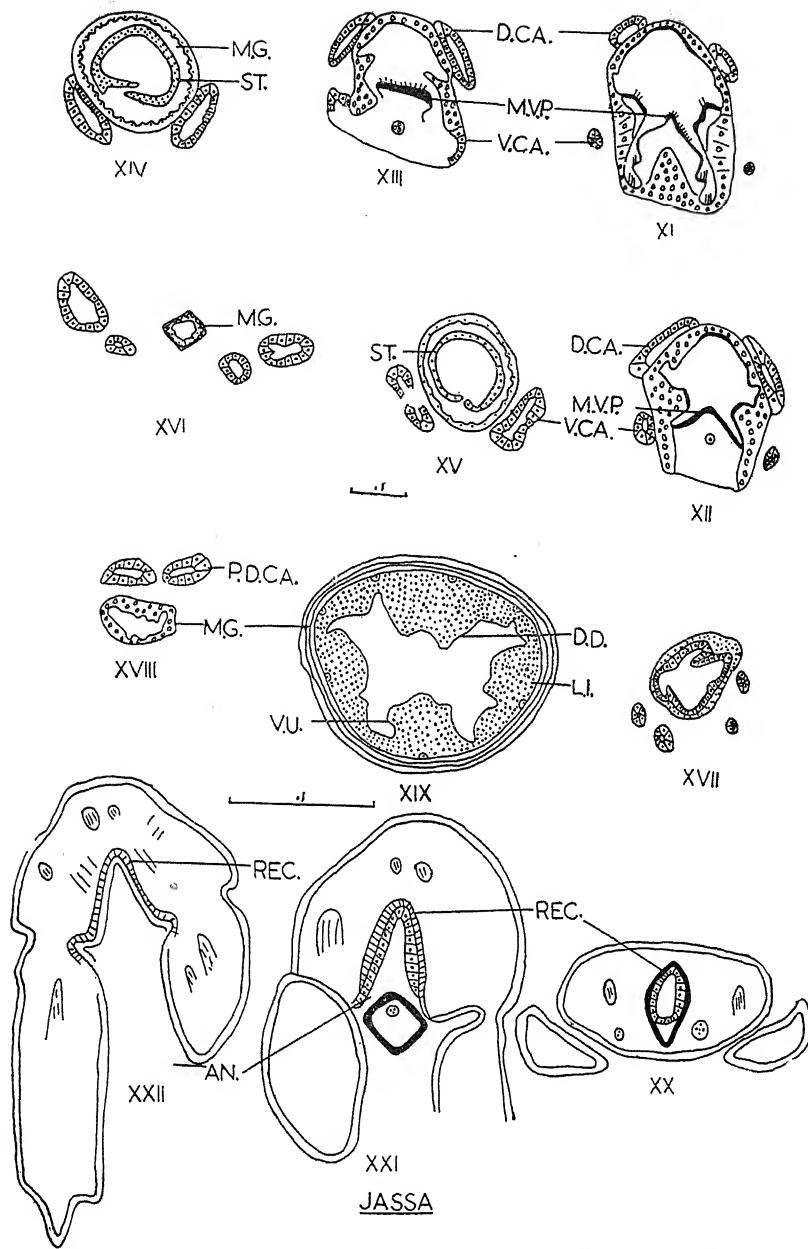
Fig. 14. *Jassa falcata* : XI and XII, T.S through foregut ; XIII to XXII, T.S. through midgut and hindgut.
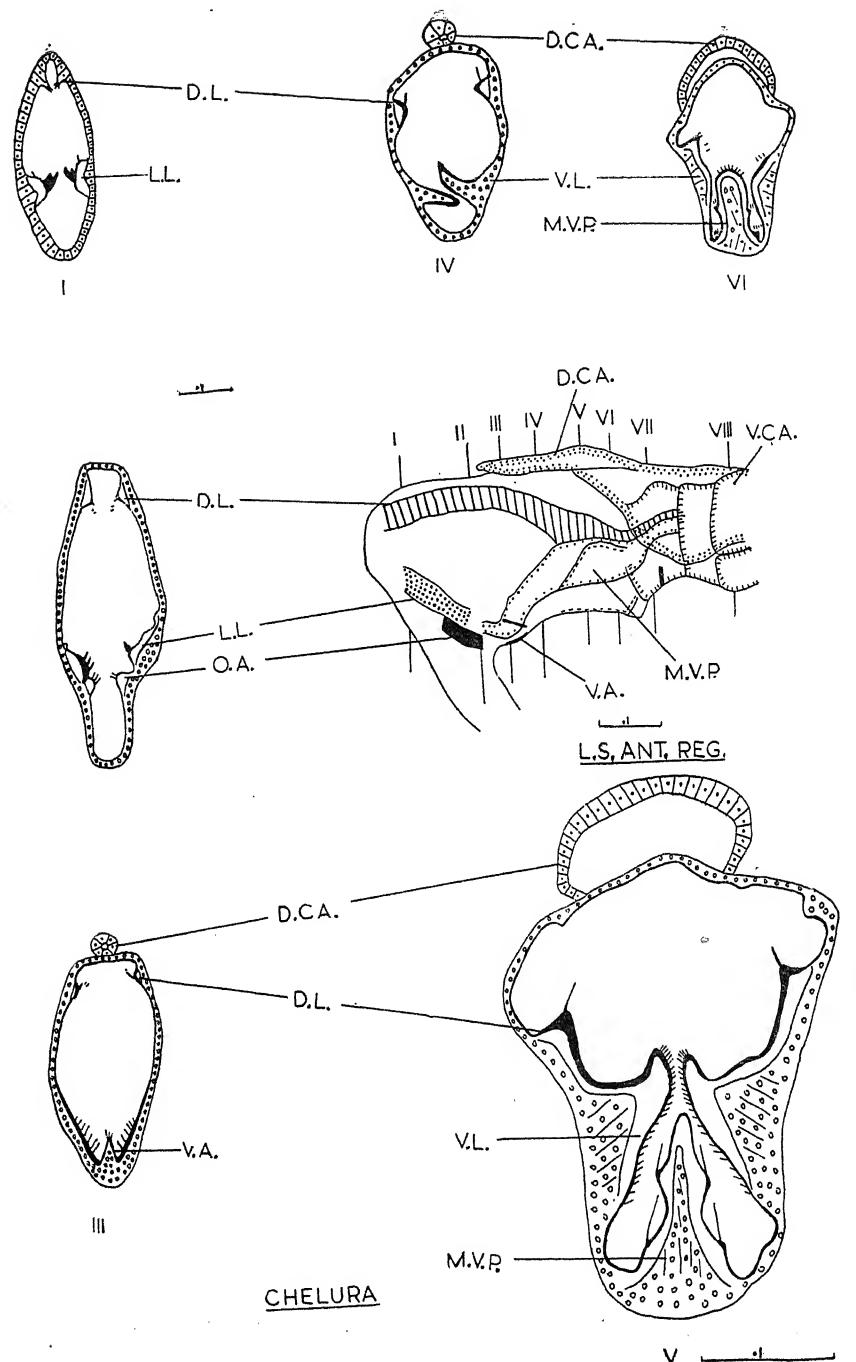
Fig. 15. *Chelura terebrans* : L.S. ANT. REG., L.S. anterior region ; I to VI, T.S. through different regions of foregut.

In between the oesophageal and lateral ridges are to be found small chitinous plates—each carrying two very long spines directed upwards (Fig. 12, II). Posteriorly, when these plates are lost, the lateral wall of the stomach is produced into a large number of small spines (Fig. 12, III). A pair of ventro-lateral ridges arise as wide structures provided with a large number of spines.

The pyloric stomach has a well developed mid-ventral piece, about 0·2 mm. long and 0·17 mm. high. The pyloric piece along with thickly chitinous ventro-lateral ridges forms an effective filter apparatus between the dorsal and ventral chambers.

The median dorsal caecum of the midgut of *Isaea*, divides into a pair of anterior dorsal caeca (Fig. 12, V, D.CA.) which run forward on either side of the stomach. A well developed chitinous caecal ridge (Fig. 12, VI, CA.A.) is also developed in this region of the midgut. The ventral caeca soon after their origin divide into two pairs of long tubular stuctures. A pair of posterior dorsal caeca arise in the region of the fourth abdominal segment.

The rectum opens to the exterior by ventral anus.

Family Jassidae

Jassa falcata (Montagu) was known as *Podocerus falcata* until 1899 when Stebbing grouped it in genus *Jassa*. Sexton (1911) and Barnard (1932) have given a brief description of the animal.

In *Jassa*, the obliquely placed oesophagus opens dorsally into the ventral part of the stomach. In a specimen, 8 mm. long, the cardiac stomach is about 0·4 mm. and the pyloric stomach is about 0·35 mm. long.

The anterior most part of the stomach has a little chitinous dorsal ridge (Fig. 13, I, D.A.) and a similar ventral ridge beset with a large number of fine spines, distally (Fig. 13, II).

A pair of dorso-lateral ridges, carrying a few small spines, are developed in the anterior part of the cardiac stomach. The lateral ridges (Fig. 13, III, L.L.) are strongly built and bear upwardly directed saw-like teeth. Above and below these lateral ridges are also present two pairs of small ridges. The oesophageal ridges (Fig. 13, V, OE.A.), bearing long spines are also present at the junction of the oesophagus and stomach.

The ventro-lateral ridges (Fig. 13, VI, V.L.), with their upper portions projecting upwards, bear a few long spines ; their lower portions extend deeper into the lumen as thick chitinous lamelliform structures overlapping each other and cut off the ventral chamber of the stomach from the rest of the stomach (Fig. 13, VIII).

The end of the cephalothrax marks the beginning of the pyloric stomach. The ventro-lateral ridges extend upwards so as to allow a narrow passage between the upper and the lower chamber. The upper margins of these ridges bear a few small spines ; their lateral margins, facing the pyloric grooves, carry a large number of small and large spines on the upper and lower sides respectivley (Fig. 13, X). The mid-ventral piece is small in the beginning, with a few spines on the top but gradually enlarges and is produced into three protuberances on each side.

Towards the middle of the first thoracic segment, the pyloric stomach passes into the midgut ; the pyloric stomach with its different ridges extends a long way into the lumen of the midgut (Fig. 14, XIV).

The median dorsal caecum, arising from the anterior part of the midgut, divides immediately into paired structures, running as small tubes on either sides of the stomach (Fig. 14, XIII).

The ventral hepato-pancreatic caeca divide into two pairs and extend backwards upto the end of the fifth abdominal segment, where they end as narrow tubes. Small, paired posterior dorsal caeca are also present.

The small rectum is thin walled and opens to the exterior through dorsal anus (Fig. 14, XXII, AN.).

Family Cheluridae

Chelura terebrans is xylophagous in habit. According to Barnard (1951) the chelurids are found in uncovered and abandoned limnoriid tunnels. Adults always inhabit the outer tiers of the eroded wood, juveniles being found in the deeper tiers. According to Bate (1865), it is one of the injurious xylophagous crustaceans and excavates the saturated wood not only for the concealment but also to feed on it.

The stomach of *Chelura* is well adapted for crushing the food particles. In an animal, about 5 mm. long, the stomach is about 0·5 mm. in length, the cardiac stomach being about 0·3 mm. long. The stomach which extends forwards beyond the mouth as a narrow pouch with a pair of dorso-lateral ridges beset with spines extends back into the midgut as far as the end of the first thoracic segment. The lateral ridges are relatively large structures being about 0·12 mm. long and 50μ wide. In the beginning, each lateral ridge has a single large flattened tooth and an upwardly directed spine (Fig. 15, I, L.L.). Posteriorly, the tooth is replaced by a large number of long spines. Spinous oesophageal ridges are also present at the junction of oesophagus and stomach (Fig. 15, II, O.A.).

The ventro-lateral ridges develop in the anterior part of the cardiac stomach and bear long spines. In the region of the pyloric stomach, they become very wide and extend into the midgut along with the dorso-lateral ridges. A median ventral ridge, bearing spines distally is also present (Fig. 15, III, V.A.).

The mid-ventral piece of the pyloric stomach is about 0·13 mm. high and 0·17 mm. long ; it has two protuberances on each side (Fig. 15, V, M.V.P.). The upper distal ends of the ventro-lateral ridges lie so close to each other that they form an effective filter apparatus between the upper and the lower chamber. Posteriorly, the pyloric piece becomes broad with comb-like spines on its two sides.

Towards the middle of the second thoracic segment, the pyloric stomach opens into the midgut. A single median anterior dorsal caecum runs forwards above the stomach. The ventral caeca run backwards in the form of two pairs of long tubular structures. The internal mucous membrane of the midgut is produced into a large number of villi.

A pair of posterior dorsal caeca arise from the midgut in the region of the third abdominal segment and run forwards upto the first abdominal segment.

The internal lining of the rectum is also produced into a few long villi especially along its dorsal and ventral margins. It finally opens to the exterior by the ventral anus.

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Discussion

It is a well established fact that the nature of the feeding mechanisms and character of structures concerned with the capture, manipulation and sorting of food are related to the kind of food taken and to its availability whether or not it is in suspension. Many authors including Yonge (1908), Cannon and Manton (1927), Dennell (1933) and Manton (1937) have examined the feeding mechanisms in Crustacea from this view point. In this study, the feeding appendages, the alimentary canals and the feeding habits of different amphipods from different habitats have been investigated.

The character of the feeding appendages and the form of the gut may be expected to be related to the character of the food taken. Under the character of the food, three different aspects are to be considered namely whether it is predominantly animal or vegetable ; the size of the food and whether the food follows a continuous or discontinuous pattern.

The size of the food is probably the most important single factor when one seeks for correlation between structure and functions of mouth parts and gut organisation. Some of the animals examined are macrophagous feeding on large masses of food, others are microphagous forms feeding on smaller food particles.

It will be better to describe the feeding habits of the different amphipods before correlating these different aspects. Among macrophagous forms, *Talitrus* commonly feeds on algal filaments and other vegetable matter. According to Bate (1857), they have been seen feeding on earthworms or even on mammal remains ; when they find nothing else, they are content to feed on each other. *Orchestia* also feeds on any vegetable matter. It has been observed by the author that they also feed happily on moist filter paper. *Orchestia* eat very large amounts of food daily ; they eat indiscriminately whatever comes their way, if it is not too dry and not too hard.

Among the true microphagous forms are to be included *Bathyporeia*, *Haustorius* and *Urothoe*. According to Hunt (1925), *Bathyporeia* is a deposit feeder selecting and picking out organic material from the substratum. It seems unlikely that the animals feed on the suspended particles in the water current. During burrowing, they feed by clearing the surfaces of sand particles.

According to Dennell (1934), *Haustorius* feeds largely on small suspended particles of organic detritus by filtering them from a stream of water produced by the mouth parts. The appendages concerned are the maxillae which work as suction pump and filter plates while the maxillipeds remove any food particles from the maxillae and pass them on to the mouth. *Urothoe*, like *Bathyporeia*, is a deposit feeder, selecting and picking out material from the substratum.

Iasea, although inhabiting the mouth parts of *Maia*, feeds mainly on diatoms and other vegetable matter. *Jassa* feeds both on larger and smaller food particles, picking them up with the help of the maxillipeds. The stomach of *Dexamine* was found full of small planktonic Crustacea on which they seem to feed.

Chelura is turly xylophagous and excavates timber not only for the purpose of concealment but with the purpose of employing it as food. According to Barnard (1951), the faeces of *Chelura* are dark in colour because they browse on the surface wood which has become darker through the action of the sea water. It is also possible that they might be browsing on microscopic organisms which grow on wood and the ingestion of the woody matter is a consequence of the scraping off their other food particles.

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It should be possible now to relate the feeding habits of these animals to the form of feeding appendages, described elsewhere (Agrawal, 1962) and to the structure of the gut.

In the macrophagous forms, the antennae, maxillipeds and anterior gnathopods are adopted for holding the food ; when the animal is feeding, these appendages cooperate to pass the food particles very near the mouth where the mandibles and maxillae bite and masticate the food particles which are then passed into the mouth. The mandibles and maxillae, in the macrophagous forms like *Orchestia* and *Talitrus* are thickly chitinous with strong curved incisors ; the molar expansions of the mandibles are prominent bulgings with deeply serrated distal edge. The palps of the mandibles and maxillae, which can hardly be of any use, are usually absent.

In the microphagous forms like *Bathyporeia*, *Haustorius* and *Urothoe*, the feeding appendages are setose for filtering the finer food particles. All the appendages are clothed with a large number of very long and feathered spines, the mandibles and maxillae are not thickly chitinous, though they are provided with large flattened setose palp.

In animals like *Jassa*, *Isaea* and *Dexamine*, which feed on large as well as small food particles, the feeding appendages are ordinarily built. The feeding appendages of *Chelura* are strongly built.

The functions of the crustacean stomach have been described by various authors. Huxley (1880) described the cardiac stomach of the crayfish as a food crushing region while the pyloric stomach works as a strainer. Ide (1892) also points to the masticatory function of the cardiac stomach and filtering mechanism of the pyloric stomach. According to Gelderd (1907), the different plates of the cardiac stomach work as auxilliaries to the mandibles. The pyloric stomach serves for the mixing up of the already masticated food with the different ferments. According to Tait (1917), the foregut is merely a propelling organ. Nicholls (1931) also considered that the stomach of *Ligia* has nothing to do with the mastication of food.

In all the animals studied here, the evidence points to the fact that the cardiac stomach is concerned with the mastication of the food while the pyloric stomach works as a strainer. The food then passes into the midgut and ventral caeca where it is digested and absorbed. The ventral hepato-pancreatic caeca secrete the different digestive enzymes. No particular function can be assigned to the anterior dorsal and posterior dorsal caeca.

Now that we have discussed the functions of the different parts of the alimentary canal, it would be convenient to correlate these variations in the structure of the gut with respect to their feeding habits.

In macrophagous forms like *Talitrus*, *Orchestia*, *Isaea*, *Dexamine* and *Jassa*, the different plates of the cardiac stomach are very strong with well developed teeth and spines for further mastication of large food particles. In microphagous forms like *Bathyporeia* and *Haustorius*, the cardiac stomach is not so well developed as in macrophagous forms, however, the lateral ridges are well developed probably to compensate for the weak development of the mouth parts of the animal. In another microphagous from, *Urothoe*, the inner wall of the cardiac stomach is almost smooth. In *Chelura* agian, the cardiac stomach is strongly built for the trituration of the hard woody food.

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The pyloric stomach serves as a sieve and allows only finer food particles to pass into its lower chamber where they come in contact with the digestive enzymes. In the macrophagous forms like *Orchestia* and *Talitrus*, the passage between the upper and the lower chamber is very narrow which is further blocked by the presence of a large number of fine bristles, arising from the distal ends of the ventro-lateral ridges. In *Dexamine*, although the passage is not very narrow, but large spines arising from the ventro-lateral ridges, retard to a great extent, the passage of the food between upper and the lower chamber. In *Chelura* also this filter apparatus is very well developed.

In microphagous forms, this passage is comparatively wide and is not very thickly covered with bristles. This may be due to the fact that these animals feed only on smaller food particles, as such there is no necessity of any selection of the food particles.

In animals like *Isaea* and *Jassa*, feeding both on larger and smaller food particles, the passage between the upper and the lower chambers is quite narrow and forms an effective filter apparatus.

The midgut of these animals does not show any remarkable difference except that in microphagous forms like *Bathyporeia* and *Urothoe*, it is very narrow anteriorly. The different hepato-pancreatic caeca, arising from the midgut, show great variations in their number, size and structure in the different animals but it seems difficult to correlate these differences with respect to their feeding habits.

In most of the amphipods, described here there is a single median anterior dorsal caecum but in some like *Haustorius* and *Jassa*, there are a pair of these caeca. In the majority of the animals there are two pairs of ventral caeca but in *Bathyporeia* and *Urothoe*, there is only one pair. It may be argued that in herbivorous forms like *Talitrus* and *Orchestia*, they are much better developed so as to provide more area for the secretion of the digestive enzymes.

Similar variations occur in the number and size of the posterior dorsal caeca which are also difficult to be explained with respect to the feeding habits of the animals.

The inner lining of the rectum also varies in the different amphipod studied. In most of these it is simple and smooth. The rectum of *Talitrus* and *Orchestia* is very complicated and is produced into a large number of well developed villi. It is perhaps a device to force out the large bulk of faeces which accumulate. It may be noted here that the animals are very active feeders and feed on practically anything that comes in the way and most of it passes out undigested.

It may now be concluded that the size of the food is one of the important factors which governs the construction of the mouth parts and the gut organisation of amphipods. In macrophagous forms, the mouth parts, especially the mandibles and maxillae, are very strongly built for the mastication of large food particles, while in microphagous forms, they are not thickly chitinous but are produced into long feathered spines for filtering. The size of the food even in the microphagous forms, is such that it has to be broken into smaller pieces so that enzymes can react readily and as this work is not shared by the mouth parts, the ridges of the cardiac stomach are well developed. However, these ridges and teeth of the cardiac stomach are very strong in all the macrophagous forms as they work as accessory masticatory organs. The pyloric stomach is also much better developed in the macrophagous forms.

These various aspects of the structure of the gut organisation and of the mouth parts are summarised in the following table :

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Name of animal	Food and feeding	Feeding appendages	Foregut	Anterior dorsal caeca	Ventral caeca	Posterior dorsal caeca	Hindgut
Orchestia	Macrophagous. Mostly vegetable	Very strong Mandibles and Maxillae	Ridges of Cardiac stomach strong with strong teeth. Pyloric stomach has well developed filter apparatus	Single median	Two pairs and large	Two pairs and large	Anterior part has chitinous spines while the inner lining posteriorly is much folded
Talitrus	Macrophagous	As above	Very similar to that of *Orchestia*	Single median	Two pairs and large	As above	Very similar
Bathyporeia	Microphagous. Mostly organic detritus	Mandibles and Maxillae are not strong All the appendages have feathered spines	Cardiac stomach has well developed ridges and teeth. Filtering mechanism of pyloric stomach is not very strong	Single median	Only one pair.	One pair and small	Simple
Haustorius	Microphagous	Large mandibles but weak and not thickly chitinous. All the appendages with very long feathered spines	Cardiac stomach strongly chitinous with well developed ridges which have serrated teeth. Pyloric stomach has a comparatively wide passage	One pair	Two pairs	A pair of very long and coiled caeca	Internal lining is folded
Urothoe	Microphagous	Mandibles and Maxillae large but weak and thin.	Cardiac stomach with wide cavity. Ridges are not strong. Weak filter apparatus	Single median	One pair of very large and wide caeca	A pair of large and coiled caeca	Simple internal lining
Dexamine	Macrophagous, feeds on small crustacea	Mandibles and Maxillae are strongly built	Cardiac stomach with a large number of spines. The pyloric stomach is also strong with very narrow passage	Single median	Two pairs	A pair of very small caeca	Simple
Isaea	Macrophagous and Microphagous	Strongly built Mandibles and Maxillae	Cardiac stomach has very strong ridges with a large number of teeth. pyloric stomach has a narrow passage	A pair of cacca	Two pairs	A pair of small caeca	Simple
Jassa	Macrophagous and Microphagous	Very large Mandibles but not very strong and are setose	Cardiac stomach does not have very strong ridges. The passage in the pyloric stomach is narrow	A pair	Two pairs	A pair of small caeca	Simple
Chelura	Xylophagous	Very strong Mandibles and Maxillae	Cardiac stomach has strong ridges with large teeth and spines. The filter apparatus is very strong.	Single median	Two pairs	A pair of small caeca	Simple

Summary

The alimentary canals of 9 species of amphipods, belonging to different families and with diverse habitats have been described to correlate their feeding habits, feeding appendages and the structure of the alimentary canal.

It is seen that the character of the feeding appendages and the form of the gut is related to the character of the food taken.

It has been found that in macrophagous forms like *Orchestia* and *Talitrus*, the mandibles and maxillae are thickly chitinous to masticate the larger food particles. In the microphagous form like *Bathyporeia*, *Haustorius* etc., the feeding appendages are setose for filtering the finer food particles. In *Jassa*, *Isaea* and *Dexamine*, which feed on large as well as small food particles, the appendages are ordinarily built. In the xylophagous form *Chelura*, the appendages are again strongly built.

In all the animals studied here, the evidence points to the fact that the cardiac stomach helps in further mastication of food while the pyloric stomach works as a strainer. The food is digested and absorbed in the midgut and the ventral caeca where the different digestive enzymes, secreted by the ventral hepato pancreatic caeca, are transmitted.

It has been found that the cardiac stomach of macrophagous forms is provided with strong ridges for further trituration of the food while in most of the microphagous forms, the inner lining of the cardiac stomach is comparatively smooth. Similar variations occur in the structure of the pyloric stomach of the different amphipods.

The different caeca, such as anterior dorsal, posterior dorsal and ventral hepato pancreatic caeca, arising from the different parts of the midgut also show characteristic differences in their size and number.

Finally, it can be concluded that the size of the food is one of the important factors which governs the construction of the mouth parts and the gut organisation of amphipods.

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A NEW SPECIES OF THE RARE ECHINOSTOME GENUS, PARALLELOTESTIS BELOPOLSKATA, 1954

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Rare as the flukes of the genus are, a single specimen of this parasite was recovered from the liver of a cattle egrett, *Bubulcus ibis coromandus*, shot near Lucknow in the month of December, 1960. A dozen egretts examined by the authors at Gyanpur, Varanasi and Allahabad, however, did not show this infection.

In the living condition, the worm is fleshy coloured and has a subcylindrical body which shows little changes of form. The pressed specimen is almost lanceolate in shape with a slight constriction at the level of the intestinal bifurcation, which divides the body into a larger and more or less spindle shaped hind body, and a smaller dome shaped forebody. The ventral surface of the latter is protruded into two lobe like masses, enclosing a median groove along the length of the oesophagus. The hind body, with maximum breadth in the region of gonads, tapers bluntly at the posterior end.
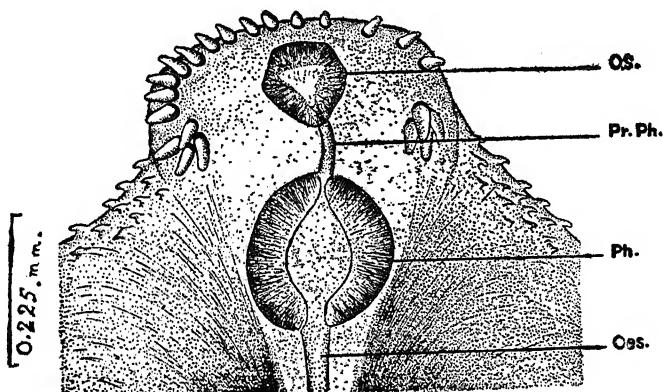
Fig. 1. *Parallelotestis indicus* sp.nov. ; anterior portion, enlarged.

The body, beset with bluntly pointed spines is 12·720 mm. long and 4·355 mm. wide at the level of the ovary. The cephalic collar, 1·105 mm. broad, is feebly developed and has a crown of 22 spines which are uninterrupted dorsally and are arranged in a single row. While the four larger corner spines on each side measure 0·0375 × 0·090 mm., the marginal ones measure 0·030 × 0·060 mm.

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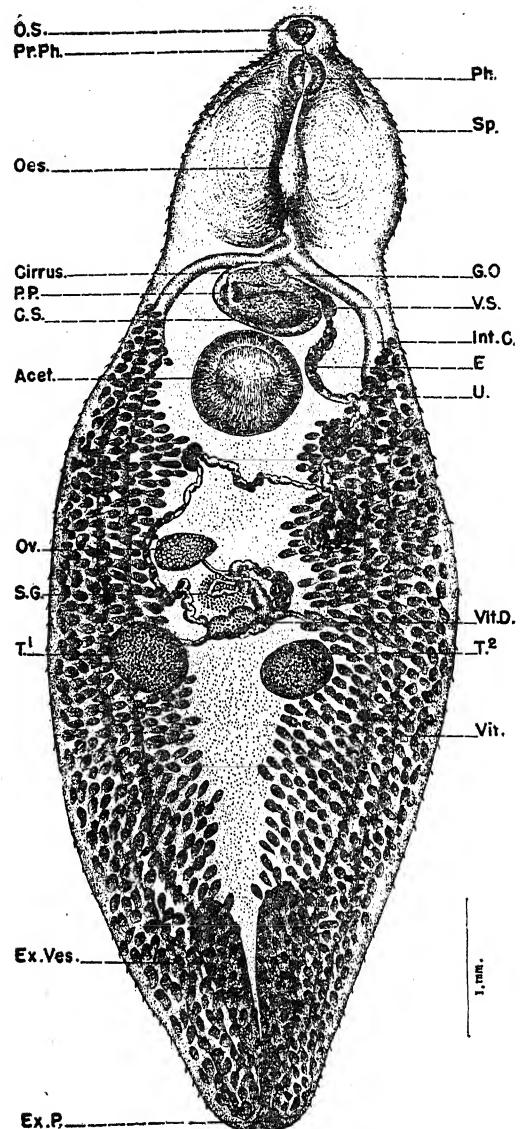
Fig. 2. *Parallelotestis indicus* sp.nov. ; entire ventral view.

KEY TO LETTERING

Acet—Acetabulum ; C.S.—Cirrus sac ; E.—Egg ; Ex.P.—Excretory
Pore ; Ex.Ves.—Excretory Vesicle ; G.O.—Genital pore ; Int.C.—
Intestinal caeca ; O.S.—Oral sucker ; Oes.—Oesophagus ; Ov.—
Ovary ; P.PP. Parsprostatica ; Ph.—Pharynx ; Pr.Ph.—Prepha-
rynx ; S.G.—Shell gland ; S.P.—Spine ; T.—Testes ; U.—Uterus ;
V.S.—Vesicula seminalis ; Vit.—Vitellaria ; Vit.D.—Vitelline duct.

The oral sucker is weakly developed and is more or less rounded in shape. Subterminally situated in the centre of the cephalic collar, it measures 0·180 × 0·195 mm. The ventral sucker is considerably large and is situated at 3·48 mm. distance from the anterior end and 0·975 behind the intestinal bifurcation. Rounded in shape, it measures 1·245 mm. across ; the ratio between the two suckers being 1 : 6.

A distinct but very short prepharynx continues into a longitudinally oblong pharynx, measuring 0·225 × 0·285 mm. The oesophagus, which is not clearly seen due to the enormity of muscles in that region, is 2·04 mm. long. The bifurcation point lies at 2·58 mm. distance behind the anterior end. The caeca, as they arise, arch over the acetabulum to reach close to the body margin, and then extend posteriorly up to the hind end of the body.

The symmetrical and intercaecal testes, lying 0·40 mm. behind the equator, have a slightly transversely elongated shape and posses entire margin. The left testis, measuring 0·750 × 0·90 mm. is somewhat bigger in size than the right one, which measures 0·825 × 0·835 mm. The two testes are separated by a distance of 2·105 mm. The sac shaped cirus sac, situated between the ventral sucker and intestinal bifurcation encloses a saccular vesicula seminalis, a pear shaped parsprostatica, and a small ejeculatory duct, the distal portion of which is beset with spines, forming the eversible cirrus. The prostate gland cells surround the structures within the cirrus sac. The genital opening is just post bifurcal.

The submedian, sinistral ovary lies 0·630 mm. in front of the left testis and 1·080 mm. behind the acetabulum, measuring 0·375 × 0·660 mm. It is roughly oval in shape. A somewhat conspicuous vitelline reservoir lying in the median line is situated just in front of the testis. Laurer's canal and receptaculum seminis could not be seen. Mehlis's gland is situated between the ovary and the vitelline reservoir. The metraterm is present. The uterus is short, containing few eggs which measure 0·075 × 0·105 mm. The vitelline follicles round to transeversely elongated in shape, extend laterally from the border of the acetabulum up to the hind end. Some of the follicles overlap the caecae and extend into the intercaecal space. They meet in the median line in the last third portion of the post testicular space.

The terminal excretory pore leads into a tubular excretory bladder.

Host :   *Bubulcus ibis coromandus*
Location :   Liver
Locality :   Lucknow, India

Discussion

Recently Beverley-Burton (1960), while describing *Parallelotestis kafuensis* has reduced the genus *Proechinocephalus* Srivastava, 1958 in synonmy with *Parallelotestis* Belopolskaia, 1954 whose genotype is *P. horridus* Belopolskaia, 1954. The present authors are in agreement with this synonymy. Thus, this genus contains besides the genotype *P. horridus* Belopolskaia, 1954, three more species viz., *Parallelotestis tarai* Srivastava, 1958 ; *P. kafuensis* Beverley-Burton, 1960 and *P. egretti* Srivastava, 1960 n.comb.

P. indicus n.sp. differs from *P. horridus* by the greater space which separates its acetabulum from the caeca and by the more posterior location of its gential opening behind the bifurcal point. Its lesser number of collar spines (22) and its greater size not only distinguish it further from the genotype but also separate it from *P. tarai, P. kafuensis* and *P. egretti*.

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UTILIZATION OF CARBON SOURCES BY *PESTALOTIA BICOLOR* ELL. ET EV. CAUSING LEAF SPOT DISEASE OF *DIOSPYROS PEREGRINA* (GAERTN.) GURKE.

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Carbon is the chief source of energy for all the living organisms. All carbon sources are, however, not of equal value for the growth and sporulation of different fungi. Tandon (1947) showed that *Pestalotia malorum* grew better on maltose, glucose and sucrose than on raffinose, galactose, and fructose. Srivastava (1955) found that the growth of *Pestalotia* sp. causing fruit rot of *Citrus medica* var. *acida* increased with the increase in the concentration of glucose. Tandon and Bilgrami (1959) reported that hexoses were utilized slowly by *Pestalotia mangiferae*. In the present investigation the influence of different sources of carbon on growth and sporulation of *Pestalotia bicolor* has been studied and the utilization of the two monosaccharides (glucose and fructose) as well as the comparative rate of utilization of varying concentrations of glucose have been determined chromatographically.

Material and Methods

The culture of the pathogen was the same as used for physiological studies carried out by Lal (1963). The details of the method used were similar to those described by Tandon and Bilgrami (1954) and the same basal medium (Asthana and Hawker's medium 'A') was used. On the basis of previous work the pH of the medium was adjusted to 5·2 before autoclaving. Three replicates were maintained. Solutions were autoclaved at 15 lb. pressure for 15 minutes. The method described by Ranjan *et al.* (1955) was followed for the chromatographic studies. The media were daily inoculated with *Pestalotia bicolor* at a fixed time (± 15 minutes) for 15 days, so that one to fifteen days old cultures could be available on the 16th day. The filtrate from each set was chromatographically analysed to detect the presence of the sugars. The dry weight of fungal mats was taken after 5, 10 and 15 days of incubation. The change in pH of the medium at the end of each incubation period was also recorded.

Observations

The organism was grown on different sources of carbon. It was observed that the growth was in patches except on media having dextrin and starch. There was no growth in the medium lacking any source of carbon. The colour of the medium did not change except on rhamnose, where it became light yellow. The thickness of the hyphae ranged from 2·3–4·1μ. They were slightly thicker on sorbose (3·5μ), sucrose (2·3–4·1μ) and thinner on malic acid (2·0μ). Pseudopycnidia were usually absent except on media having xylose, maltose and malic acid. Their size varied from 37·5–150·0μ. In general the spores measured from 23·0×6·9μ–24·2×5·8μ, but they were slightly smaller on media having glucose (20·7×5·8μ), sorbose (21·9×6·4μ), sucrose (21·9×5·8μ) and sorbitol (21·9×6·4μ), while they were larger on dextrin (24·4×5·8μ) and starch (25·3×6·4μ). The

result was analysed satatistically. The dry weight and sporulation of *Pestalotia bicolor* on different carbon compounds are recorded in table 1.

TABLE 1

Showing dry weight and sporulation of *Pestalotia bicolor* on different carbon sources.

Carbon compounds	Dry weight in mg.	Sporulation
1. Xylose	64·86	Poor
2. Rhamnose	52·20	Poor
3. Glucose	85·20	Fair
4. Fructose	64·26	Good
5. Sorbose	74·66	Excellent
6. Sucrose	80·86	Good
7. Maltose	71·00	Fair
8. Lactose	42·53	Absent
9· Raffinose	73·66	Fair
10. Dextrin	75·53	Good
11. Starch	64·33	Fair
12. Sorbitol	74·33	Good
13. Mannitol	74·13	Fair
14. Malic acid	24·53	Absent
15. No carbon	0·00	Absent

General mean = 61·45 mgs.

Summary of the dry weight results and conclusions at 5% level of probability are given below :

Treatments   ...   Highly significant
Replicates   ...   Non–significant
S.E.   ...   0·53
C.D. at 5% level = ± 1·5

Carbon compounds
Dry weight in mgs.

| Glucose\ 85·20 / | Sucrose\ 80·86 / | Dextrin 75·33 |

| Sorbose 74·66 | Sorbitol 74·33 | Mannitol 74·13 | Raffinose\ 73·66 / |

| Maltose 71·00 \ / | Xylose 64·86 | Starch 64·33 | Fructose\ 64·26 / |

| Rhamnose\ 52·20 / | Lactose\ 42·53 / | Malic acid\ 24·53 / | Control 0·00 |

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It is clear from the results that glucose was the best and rhamnose, lactose and malic acid were poor sources of carbon. The relative utility of various substances is indicated above.

The decoction of healthy leaf showed bands of sucrose (Rf. 0 46) and fructose (Rf. 0·54) on the chromatogram. It was further noticed that the bands of fructose and sucrose were more prominent than those of glucose.

It is thus obvious that the above three substances are available to *Pestalotia bicolor* from the host tissues. Physiological studies also indicate that all of them were good sources for the growth of the organism. It was, therefore, considered desirable to study the utilization of the two most important monosaccharides, glucose and fructose. The dry weight, final pH and utilization of sugars by the organism are recorded in table 2.

TABLE 2

Sugars	Dry weight in mgs.			Initial pH	Final pH			Sugar utilized in days
	5 days	10 days	15 days		5 days	10 days	15 days	
Glucose								
5 gms/l.	71·4	86·6	83·0	5·2	6·1	6·7	7·0	5
10 gms/l.	230·8	454·4	379·0	,,	,,	,,	,,	10
20 gms/l.	148·9	268·8	261·1	,,	,,	,,	,,	10
40 gms/l.	327·6	348·6	494·0	,,	,,	,,	,,	13
Fructose								
10 gms/l.	199·0	352·4	329·0	,,	,,	,,	,,	12

The organism showed an increase in dry weight on the above two monosaccharides up to 10th day after which a fall was recorded, except when 40 gms/l. of glucose was used, where the growth continued to increase up to 15 days. The rate of increase in dry weight was greater in the beginning of the incubation period because of the high concentration of the sugar available to the organism, but it declined as the concentration decreased. Finally, when no sugar was left in the medium the dry weight did not increase, and possibly due to autolysis there was a slight decrease.

Discussion

Lilly and Barnett (1951, p. 120) write that glucose is utilised by more fungi than any other sugar and is nearly an universal carbon source. The results of the present studies confirm this because this substance is found to be the best source of carbon. Margolin (1942), Bhargava (1945), Bilgrami (1956), Raizada (1957), Tandon and Bhargava (1960), and many others have also obtained similar results. Prasad (1963) as well as Tandon and Mitra (1963) reported that maltose was the best source for the growth of *Pestalotia pauciseta* and *Pestalotiopsis versicolor* respectively.

All the carbon sources tried were found to be good except rhamnose, lactose, and malic acid, poor response on organic acid has also been reported by Leben and Keitt (1948) for *Venturia inaequalis*. Sorbose was found to be an excellent source for the sporulation of the organism. Tandon and Mitra (1963)

have found that *Pestalotiopsis versicolor* did not sporulate on sorbose. Sporulation was absent on lactose and malic acid. Tandon and Mitra (1963) have also reported the absence of sporulation on the above substances.

The days of utilization of glucose from the medium increased with the increase in the amount of this substance up to 10 gms/1. The period was similiar at 20 gms/1. but it again increased when the quantity of glucose was doubled. It is thus evident that the rate of utilization increased with increase in the concentration of this hexose.

Summary

The growth of *Pestalotia bicolor* was best on glucose. Rhamnose, lactose and malic acid were poor sources of carbon. The organism was found to be incapable for growth in complete absence of any carbon source. The sporulation was excellent on sorbose while it was absent on lactose, malic acid and on media lacking carbon. Chromatographic analysis of the media having 5 gms, 10 gms, 20 gms and 40 gms per litre of glucose showed the utilization in 5, 10, 10 and 13 days respectively. 10 gms/1. of fructose was utilized in 12 days.

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SOME UNECONOMICAL SEEDS AND FRUITS AS SOURCE OF CULTURE MEDIA FOR FUNGI—I

By

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Introduction

India represents a wide range of climate, topography and geology and its flora too is enormously varied. However, seeds and fruits of many plants, cultivated or wild, are generally regarded as waste products and are thus thrown away. Gupta (1960) made an attempt to make use of some such waste seeds and fruits of Naini Tal area for preparing culture media for the growth of fungi.

In the present work a number of plants of Gyanpur vicinity, whose fruits and seeds are available in abundance but go waste, were taken up with a view to find out their comparative value in the preparation of culture media in comparison to more commonly used potato and other media for growing different fungi.

Materials and Methods

The culture of *Alternaria tenuis* Nees ex Pers, an isolate from sunflower plant causing leaf spot disease, was obtained from the stock cultures of K. N. Government College, Gyanpur. The culture was maintained on potato-dextrose—agar medium (20% potato, 2% glucose and 2% agar) in the culture tubes at 25°C and renewed at 10 days intervals.

Fruits of yellow 'Kaner' *(Thevetia neriifolia)* 'Amaltas', *(Cassia fistula)* and 'Panwar' *(Cassia obtusifolia)* and seeds of mango *(Mangifera indica)* and tamarind *(Tamarindus indica)* were collected locally. The fruits of 'Amaltas' and 'Chakwar', the cotyledons of ripe mango seeds and seeds of 'tamarind' were cut into small pieces. Only 200 gms. of each of them was separately boiled in distilled water for one hour, strained through fine muslin and its final volume made to one litre by addition of distilled water. Potato decoction was also prepared by the above method using potato tubers. For the preparation of lucerne medium, 10 gms. of powdered lucerne seeds *(Medicago sativa)* was taken in 100 ml. of distilled water in a beaker and kept at 100°C on a water bath for an hour, stirring several times. The decoction was then filtered through fine muslin and the filtrate again made to 100 ml. by adding distilled water.

When media of lower concentrations were required, they were prepared by diluting the above mentioned media.

Both liquid and solid media were used, the latter were prepared by adding 2 gms. of agar in 100 ml. of the decoction.

The sterilization of media was done by autoclaving it at 15 lbs. pressure for 20 minutes.

For measuring the linear growth of the fungus, only 10 ml. of natural agar medium was taken in sterilized Petri dishes. Inoculations were done in the centre of the Petri dish by transferring a few spores of the fungus, The Petri

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dishes were incubated at 25°C–27°C and the radial spread of the colonies was measured at regular intervals.

For counting the spores, three discs, each of 7 mm. diameter were cut with the help of a cork borer from a colony of 6 cm. diameter. Each disc was kept in 5 ml. of distilled water in a tube and shaken to spread the spores homogenously. Liquid from each dilution was kept on a haemacytometer slide, mounted with cover glass and the number of spores were counted under single microscopic field. Three readings were taken of each preparation and the mean of 9 readings was then recorded.

For calculating the percentage of germination of spores, the latter were first germinated on decoction media by hanging drop method and after 24 hours the number of germinated spores out of the total number present in one microscopic field were counted. The percentage of germination was then calculated.

For obtaining the dry weight of the mycelium, 20 ml. of each decoction medium was taken in flat culture bottle of 12 oz. fluid capacity, sterilized under 15 lbs. pressure for 20 minutes and inoculated by transferring a few spores. The spores were evenly distributed by shaking the culture bottles before they were stacked on their flat sides in an incubator for 2 to 10 days at 25°C–27°C. After the incubation period, the fungal mats were carefully removed, washed with warm distilled water, dried at 70°C–80°C in an electric oven for 24 hours and weighed. The liquid medium left after removing the mycelium was centrifuged at 4,000 r.p.m. for 10 minutes and then used for testing protopectinase and cellulolytic enzymes.

The activity of protopectinase enzyme (PP) was determined by potato disc method of Brown (1915) at room temperature (22°C–30°C).

Cellulase (Cx) activity was assayed by viscosity measurements (Reese *et al*, 1950 ; Bell *et al*, 1955). For this 0·5% solution of CMC (Carboxyl methyl cellulose) was used as substrate. Only 5 ml. of this solution was mixed with 1 ml. of enzyme and the fall in viscosity was regularly measured over a period of 20 minutes at 30°C in a water bath using Ostwald's viscometer.

Percentage of cellulase (Cx) activity was calculated by the following formula :

$$\frac{A \times 100}{B}, \text{ where}$$

A—indicates the assumed total fall of viscosity from initial reading to that of distilled water and

B—is the actual fall of viscosity in 20 minutes in that particular set of experiments.

Experimental Results

(a) *Effect of different decoction media on growth* :

Fruits of 'Kaner' (*Thevetia neriifolia*), 'Amaltas' (*Cassia fistula*) and 'Panwar' (*Cassia obtusifolia*), seeds of mango (*Mangifera indica*), tamarind (*Tamarindus indica*) and lucerne (*Medicago sativa*) ; and tubers of potato were used to prepare both liquid and solid media.

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Linear growth of the fungus was measured on 20% decoction agar media in all cases except with lucerne and mango, where the concentrations were 10% and 20% respectively. For measuring the dry weight of the mycelium on various natural media, decoctions of different concentrations were used.

TABLE I

Growth (dry weight) on different concentrations of media

Decoction of	Concentration	Dry weight of the mycelium in mg after				
		2 days	4 days	6 days	8 days	10 days
Tamarind	20%	4	8	28	64	104
,,	15%	2	7	22	48	86
,,	10%	2	6·4	18	32	52
,,	5%	1·8	4·6	16	24	32
,,	2%	*	3	12	18	28
,,	1%	*	*	8	14	22
'Kaner'	20%	22	30	36	50	30
,,	15%	17	22	30	36	22
,,	10%	10	16	22	32	20
,,	5%	8	14	20	26	24
,,	2%	*	*	*	*	*
,,	1%	*	*	*	*	*
Lucerne	10%	86	156	148	84	80
,,	5%	52	88	96	92	84
,,	2%	36	58	66	68	52
,,	1%	28	46	54	60	50
'Amaltas'	20%	32	38	46	54	86
,,	15%	26	32	36	45	62
,,	10%	20	28	30	38	42
,,	5%	14	22	28	32	38
,,	2%	*	12	22	26	30
,,	1%	*	*	*	*	*
'Panwar'	20%	10	22	50	80	96
,,	15%	8	16	30	58	64
,,	10%	5	12	22	46	50
,,	5%	*	8	17	34	42
,,	2%	*	*	12	28	32
,,	1%	*	*	*	*	*
Potato	20%	26	60	68	54	42
Mango	2%	2	4	8	14	20
,,	1%	*	4	6	10	16

*No growth of the fungus.

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Comparative results of linear growth and dry weight obtained in this set of experiments are shown in Tables I and II. As there was no growth of the fungus on mango media of 5% or higher concentrations, it has not been shown in the results.

TABLE II

Growth (linear) on different natural media

Deccoction of	Concentration	Linear growth of the fungus in mm. after				
		2 days	4 days	6 days	8 days	10 days
Tamarind	20%	16	32	48	68	84
'Kaner'	20%	16	32	50	60	68
'Amaltas'	20%	16	32	54	72	94
'Panwar'	20%	18	32	52	60	88
Potato	20%	12	28	38	44	52
Lucerne	10%	8	32	52	60	64
Mango	2%	16	38	58	80	100

Out of the various decoction media, the dry weight of the mycelium on the lucerne medium was found to be most satisfactory (Table I). However, the fungus gave appreciable amount of dry weight of the mycelium on tamarind decoction and the growth was satisfactory even at a concentration of 5% (Table I).

'Amaltas' and 'Panwar' decoction also supported good mycelial growth. However, the growth of fungus decreased with the decrease in the concentration of the media (Table I).

The media prepared from tamarind, 'Amaltas' and 'Panwar' were also adjudged to be better than potato from another angle as in the latter case lysis started after 6–8 days, while in the former three media the dry weight of the mycelium continued to increase even up to 10 days.

The radial spread of fungal growth was found to be better on 20% 'Amaltas', 20% 'Panwar' and 2% mango than rest of the media (Table II).

(b) Effect of different decoction media on sporulation :

The fungus was grown on different natural agar media in Petri dishes of 10 cms diameter and the sporulation was calculated as described earlier. The results obtained are given in Table III.

Table III shows that the Petri dish containing the medium of 'Amaltas' got filled earlier than the others and the sporulation was also comparatively better in this case. It is also clear from the above results that the spores are formed in lesser number where a Petri dish took longer time to get covered by the mycelium. So the 'Amaltas' medium was found to be the best medium for the sporulation of the fungus.

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TABLE III

Sporulation on different media

Medium	Days to cover the Petri dish	No. of spores
20% Tamarind	12	18
20% 'Kaner'	18	10
20% 'Amaltas'	<10	35
20% 'Panwar'	12	24
20% Potato	16	14
10% Lucerne	15	22
2% Mango	10	20
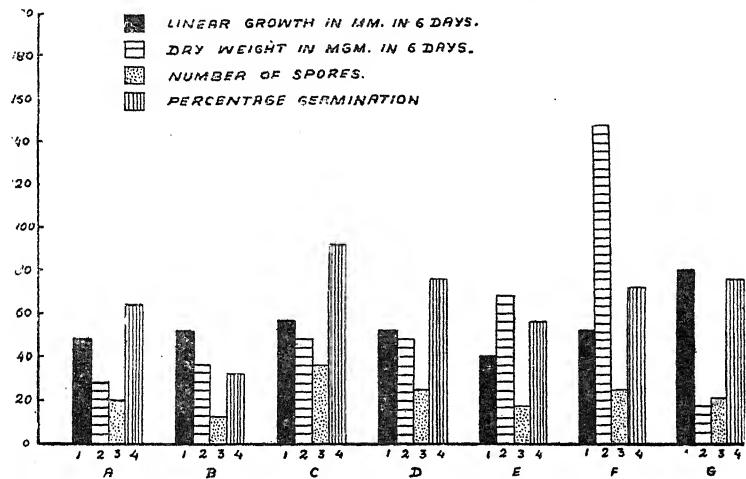
Fig. 1. Growth, Sporulation and spore germination of the fungus on different media. A–20% tamarind; B–20% 'Kaner'; C–20% 'Amaltas'; D–20% 'Panwar'; E–20% potato; F–10% lucerne and G–2% mango.

When linear growth, dry weight, sporulation and spore germination of the fungus on different media were compared (Fig. 1) the potato medium ranked not only sixth in order of preference for spore formation, but also it was found to be very poor for the linear growth of the fungus.

It was also noted that spore formation has no definite relation with either linear growth or dry weight of the fungus (Fig. 1). The maximum number of spores were formed on 'Amaltas' medium while best linear growth was on mango and maximum dry weight was on lucerne medium.

(c) *Effect of different natural media on spore germination* :

Spores of the fungus were germinated on the decoction of different natural media and compared with the germination on distilled water. The method of calculating the percentage of germination is given earlier. The results obtained are given in the Table IV.

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TABLE IV

Effect of different media on the spore germination of A. tenuis

Medium	Concentration of medium	% of germination
Tamarind	20%	64
'Kaner'	20%	34
'Amaltas	20%	90
'Panwar'	20%	74
Potato	20%	54
Lucerne	10%	74
Mango	2%	75
Distilled water	—	30

It is evident from the results (Table IV) that the percentage of germination of spores was most satisfactory in the case of 'Amaltas' medium. Potato decoction stood sixth in order of preference, 'Amaltas', mango, 'Panwar', lucerne and tamarind being better. Germination of spores was very poor in the medium of 'Kaner'.

Like the spore formation on different media, germination of spores also did not show any relation with the growth of the fungus (compare Fig. 1 and Table IV).
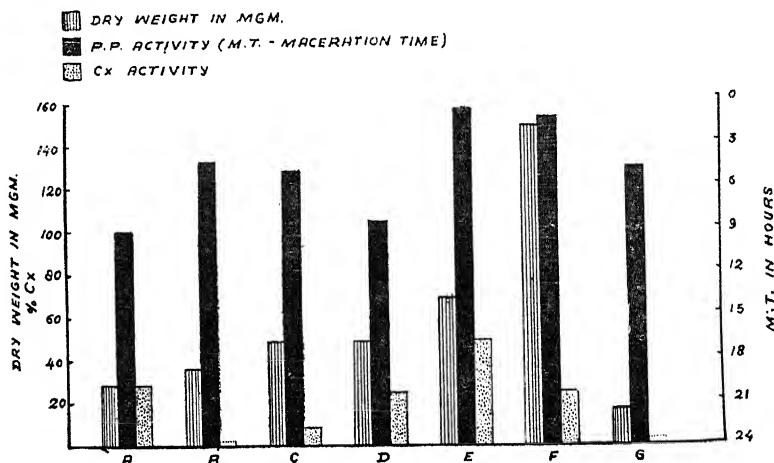
Fig. 2. Dry weight, PP activity and Cx activity of the fungus on 20% tamarind (A), 20% 'Kaner' (B), 20% 'Amaltas' (C), 20% 'Panwar' (D), 20% potato (E), 10% lucerne (F), and 2% mango (G) after 6 days incubation period.

(d) *Effect of different natural media on pectic enzyme secretion* :

Different concentrations of the different natural media were used for testing the protopectinase enzyme activity as described earlier. The results are shown in Table V.

TABLE V

Secretion of protopectinase enzymes on different media

Medium	Maceration time in hours after				
	2 days	4 days	6 days	8 days	10 days
20% Tamrind	>14	10	8½	8	6½
15% ,,	>24	21	18	16	13
10% ,,	>24	>24	22	20	17
5% ,,	24	>24	22	19	17
2% ,,	*	>24	>24	>24	18
1% ,,	*	*	>24	>24	>24
20% 'Kaner'	8	5½	4	2¼	2¼
15% ,,	7	4	3	2	4
10% ,,	6	3½	2½	2	3
5% ,,	10	8	6½	4½	7
2% ,,	*	*	*	*	*
1% ,,	*	*	*	*	*
10% Lucerne	1½	1	1½	2¼	4
5% ,,	3½	2¼	2	1½	3
2% ,,	5	3½	2½	2	3½
1% ,,	7	6	4	2½	5
20% 'Aaltas'	6	5	4¼	3	2½
15% ,,	9	8	6½	4	5
10% ,,	10	8½	7	5½	7⅓
5% ,,	12	6	8	6½	9
2% ,,	*	>24	18	16	20
1% ,,	*	*	*	*	*
20% 'Panwar'	12	9	.8	7	6
15% ,,	10	8	6½	5	7
10% ,,	14	12	10½	8½	11
5% ,,	16	13	10	10	12
2% ,,	*	*	>24	>24	>24
1% ,,	*	*	*	*	*
20% Potato	2½	2	¼	¼	1
2% Mango	8½	5	4½	3½	4
1% ,,	*	10	7	6½	5

Very active enzyme was not obtained in most of the media as is clear from Table V. However, comparatively more active enzyme was secreted by the fungus on potato, lucerne and 'Amaltas' decoctions. An incubation period of six to eight days was found to be equally good for the fungus with different media.

Though 20% decoction of 'Kaner' was not good for enzyme secretion, but its lower concentrations (10–15%) gave better production of the protopectinase enzyme.

By critically studying the Table V, it becomes clear that 20% potato decoction in general was better than any other decoction for the production of protopectinase enzyme by the fungus.

(e) Effect of different decoction media on cellulolytic enzyme secretion.

Cellulolytic (Cx) enzyme secretion on different media by the fungus was studied by the method described earlier. The resultes are shown in Table VI.

TABLE VI

Secretion Cx after 6 days of incubation

Medium	Concertration of medium	% of Cx
Tamarind	20%	28
'Kaner'	20%	0·0
'Amaltas'	20%	8
Panwar	20%	23·2
Potato	20%	46·4
Lucerne	10%	24·1
Mango	2%	0·0

From the Table VI it is clear that Cx enzyme was best secreted by the fungus on potato decoction medium. A low cellulolytic (Cx) activity of the fungus was also recorded on tamarind, 'Panwar' and lucerne media, while on rest of the media it was negligible.

By comparing the Fig. 2, it becomes clear that protopectinase and Cx enzyme secretion on different natural media did not increase or decrease to the same extent. Cx enzyme, like that of PP, also did not show any relation with the growth of the mycelium.

Summary and Conclusions

The fruits and seeds of five plants which go waste but are produced in abundance, were tested for their value as culture media for growing fungi.

The growth of the fungus (*Alternaria tenuis*) was found to be better on tamarind (*Tamarindus indica*), 'Amaltas' (*Cassia fistula*), 'Panwar' (*Cassia obtusifolia*) and mango (*Mangifera indica*) decoctions than potato decoction. Sporulation of the fungus was found to be comparatively better on 'Amaltas' medium than others while potato medium ranked sixth for the same purpose. The spore germination was also found to be best on 'Amaltas' medium, while potato medium

was fifth in order of preference. However, potato decoction was found to be better than other media for the secretion of pectic and cellulolytic enzymes.

On the basis of this work it was concluded that many waste fruits and seeds of Indian plants can serve as better medium than the more normally used potato medium. In general, decoctions prepared from the seeds of tamarind and fruits of 'Amaltas' were found to be better than potato decoction for culturing the fungus.

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MORPHOLOGY OF FURIT PROJECTIONS. I. *RICINUS COMMUNIS* L. AND *DATURA METEL* L.

By

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Introduction

Morphology of fruit projections (*viz.* spines, prickles and emergences present on the fruit walls) of various Angiosperms has not attracted as much attention as the subject deserves. The terminology used for these structures is sometimes improper and also confusing.

Hooker (1885) described the capsule of various species of *Datura* to be spinous, while Kirtikar and Basu (1918) considered it to be prickly. Haines (1921) defined the capsule of *Datura* to be spinous ; but later he used the term prickles for the projections present on the fruits. In course of the same description he again called them spines.

The fruits of *Ricinus* are described prickly by workers like Brandis (1911) and Duthie (1915). Kirtikar and Basu (1918) described them echinate and Bamber (1916) considered the fruit to be smooth or tuberculate.

McLean and Cook (1956) used the terms 'prickles and hard hairs' for the projections present on fruit walls of many Angiosperms.

This difference in the concept of various workers is obviously due to the scarcity of the literature on the morphology of these organs. It is partly also due to the non-critical approach to the correct use of these terms.

The author therefore, proposes to rectify some of the inaccuracies and confusions with the help of morphological investigations. This communication deals with the morphology of the projections present on the fruit wall of *Ricinus communis* L. and *Datura metel* L.

Material and Methods

Ricinus communis L. and *Datura metel* L. grow extensively in a wild state, within this locality ; from where the material was collected and fixed in formalin-acetic acid-alcohol. Routine methods of dehydration and embedding were followed. Sections $10\text{-}12\mu$ thick were cut, stained with saffanin and fast green and mounted in canada balsam.

Vascular system of these projections was studied by clearing procedures using HNO_3 and $NaOH$ or Chloralhydrate as clearing reagents and also anatomically by cutting sections at various levels.

Observations

Clearing procedures have proved useful for the study of vascular system of the projections. Such a mount of *Ricinus* fruit wall shows a few vascular traces, which arise from a reticulum in the fruit wall and enter the fruit projection.

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These vascular traces later on, branch (fig. 1). The vascular branches in their turn ramify and produce minor branches; thus producing a large number of vascular elements which appear scattered in the transverse section of a projection (fig. 2). Towards the apical part of the projection there remain only a few vascular elements (figs. 3—6), which have definite arrangement—a bundle in the centre surrounded by a few groups of vascular elements (fig. 6).

In case of *Datura* also, a large number of vascular traces, from the reticulum of the fruit wall, enter the projection (Photo 1). The vascular traces branch and thus produce a large number of vascular elements arranged in a cyclic manner (fig. 10).

Anatomy of the projections—The projections present on the fruit walls of *Ricinus* and *Datura* are simple in structure. The epidermis of *Ricinus* projection has widely distributed stomata on its surface (fig. 8). In a transverse section a projection is composed of parenchymatous cells with frequent intercellular spaces. Distinct xylem groups consisting of 2—5 cells are present.

In the case of *Datura* fruit projection, the epidermis is covered over by multicellular trichomes, which are uniseriate, with or without a globose apex (fig. 12). In a transverse section (fig. 11), a projection shows an epidermis followed by three or four layers of large parenchymatous cells with frequent intercellular spaces ; this is followed by a zone 3 or 4 cell layers deep, composed of compact parenchymatous cells. It is in this zone that the vascular elements are present. Xylem is present in groups of one to three cells, phloem ; however, is indistinct. The central part of the projection is composed of large parenchymatous cells.

Discussion

According to the Jackson's authoritative "Glossary of Botanic Terms" (1916) *'a prickle is an outgrowth of the rind or bark'* ; it may not therefore have any vascular supply. Projections present on the fruit walls of *Ricinus* and *Datura* have well defined vascular traces. It is thus improper to call them prickles. Jackson defined a spine as *'a sharp pointed woody or hardend body, usually a branch, sometimes a petiole, stipule or other part of a plant body'*. According to this definition a spine is likely to have a vascular supply. The projections of *Ricinus* as well as of *Datura* fruit walls show the presence of well defined vascular traces ; it is therefore, justified to call them spines.

The vascular supply to the fruit wall in both the cases—*Ricinus* and *Datura*—forms a reticulum or a closed net comparable to a leaf, from which several vascular branches depart and supply the spines. Vascular traces supplying the spines are mostly branched, the branching being almost similar to that present in the fruit wall. Hence the spines of *Ricinus* as well as of *Datura* being the outgrowths of their respective ovary walls may be morphologically interpreted to be appendicular.

In order to remove the existing terminological confusion we may emend the definition of the spine, which should now be as follows :

"A spine is a sharp pointed woody or hardend body *provided with a distinct vascular supply*, it may be a branch, a petiole, a stipule or other part of a plant body."

Summary

Morphology of the fruit projections of *Ricinus communis* L. and *Datura metel* L. has been investigated. The projections present on the fruit walls of *Ricinus* and

ep,—epidermis ; p,—parenchyma ; ip,—inner parenchyma ; mp,—middle par.
enchyma ; op,—outer parenchyma ; ph,—phloem ; st,—stoma ; xy,—xylem.
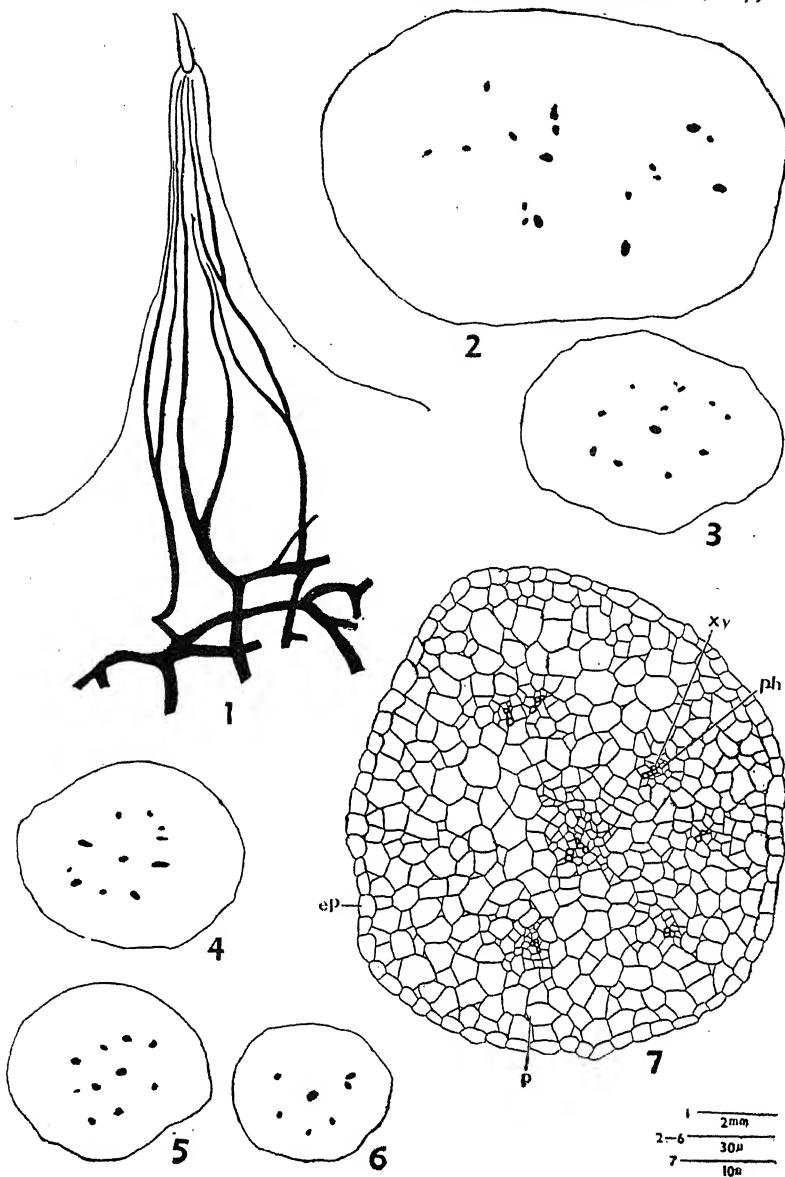
Ricinus communis L.

Fig. 1. A clear mount of a fruit projection showing a few vascular strands
entering the projection from the reticulum of fruit wall and the
branching of these vascular strands.

Figs. 2—6. Serial transverse sections of a fruit projection, (from base to
apex) showing the arrangement of vascular strands.

Fig. 7. A transverse section of a projection showing its anatomical structure.
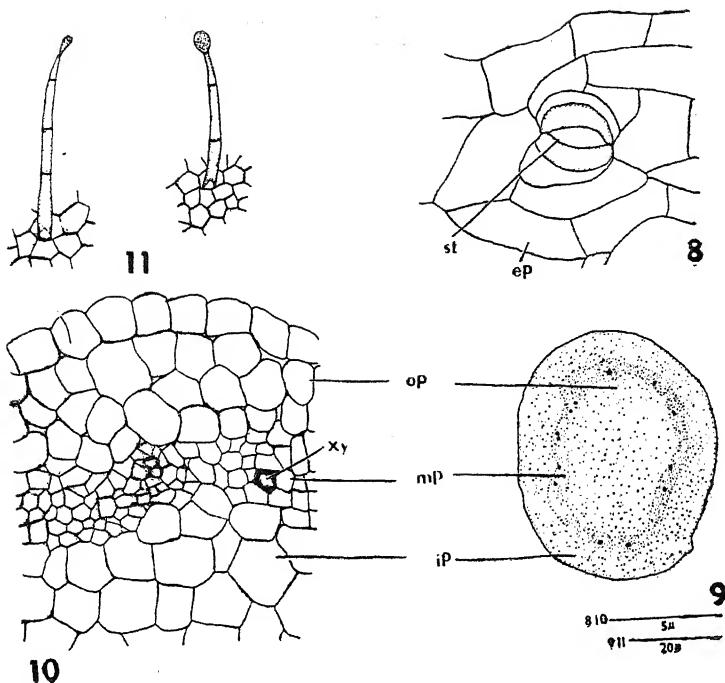
Fig. 8. *Ricinus communis* L.   Epidermal surface of a projection showing
the stoma.

Figs. 9–11.   *Datura metel* L.   Fig. 9.   A transverse section of fruit pro-
jection showing the arrangement of the tissues.

Fig. 10.   A magnified portion of the transverse section of a fruit pro-
jection showing the composition of the tissues.

Fig. 11.   Trichomes.
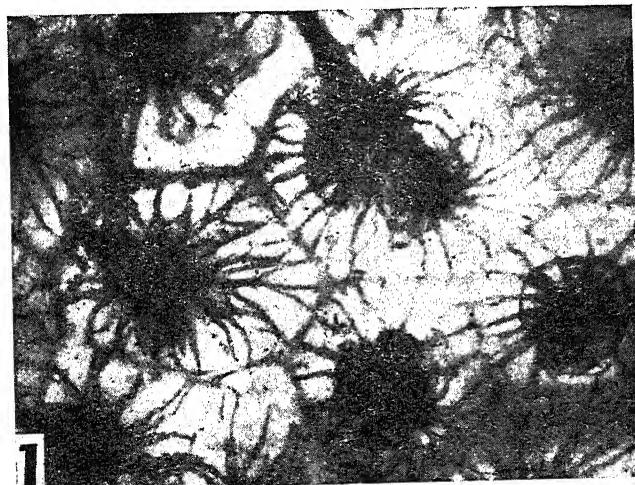
Photo 1.   A photograph of a clarified portion of the fruit wall of
Datura showing the departure of vascular strands from
the fruit wall to the projections.   (Natural size X7).

Datura are morphologically spines which are appendicular in nature. Emended definition of the spine has been provided.

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NEW COMBINATIONS IN THE FAMILY POLYPODIACEAE—II*

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In the course of our investigation into the Cytotaxonomy of the family Polypodiaceae (sensu stricto) in Eastern India, a thorough study of literature on the subject necessitated the making of the following new combinations in the two genera viz, *Pleopeltis*, and *Crypsinus*. Comments on the taxonomic treatments of the different species and important notes on their habits, habitat and distribution have been appended to every species.

Pleopeltis contorta (Christ) Panigr. and Patn. comb. nov. Basionym— *Polypodium contortum* Christ. Bot. Gaz. **51** : 347, 1911. Synonym—*Lepisorus contortus* (Christ) Ching. Bull. Fan Mem. Inst. Biol. **4** : 90, 1933. *Polypodium lineare* Fr. Pl. David. in Nouv. Archiv. 11, 7, 354, 1883. The Indian specimens identified to this species are presumed to have been included by Beddome in the *Pleopeltis linearis* complex.

In the Regional Herbarium Shillong, there are a large number of specimens collected from Assam, NEFA and Sikkim.

Pleopeltis excavata (Bory ex Willd.) Sledge var. *scolopendria* (Ham. ex Don) Panigr. and Patn. comb. nov. Basionym—*Polypodium scolopendrium* Ham. apud Don Prod. Fl. Nepal. 1, 1825. Synonym—*Lepisorus excavatas* (Bory) Ching, var. *scolopendrium* (Ham.) Ching, Bull. Fan Mem. Inst. Biol. **4** : 69, 1933. *Pleopeltis simplex* (Sw.) Bedd. Handb. 347, 1883 (in part).

Pleopeltis loriformis (Wall. ex Mett.) Moore var. *steniste* (Clarke) Panigr. and Patn. comb. nov. Basionym—*Polypodium lineare* Thbg. var. *steniste* Clarke, Tr. Linn. Soc. II. Bot. **1** : 559, 1880. Synonym—*Pleopeltis linearis* var. *steniste* Bedd. Handb. 347, 1883. *Lepisorus loriforme* (Wall.) Ching var. *steniste* (Clarke) Ching, Bull. Fan Mem. Inst. Biol. **4** : 82, 1933.

This variety reported by Clarke from Sikkim (Bedd. l.c.) has since been collected from Kameng Frontier Division (Vide *Panigrahi 6315, Rolla 8118*).

Polypodium linearis var. *steniste* Clke. is treated here as a variety of *Pleopeltis loriformis* Wall. ex Mett. with which it resembles in having its rhizome scales concolourous without any dark central band whereas *Pleopeltis thunbergiana* Klf. (to which *P. linearis* Thbg. is synonymous, cf. Copeland E. B., *Genera filicum* : p. 183, 1947 and C. Chr. Ind. Suppl. III : 160, 1934) is characterised by rhizome scales being discolourous with a central band.

Pleopeltis macrosphaera (Bak.) Panigr. and Patn. comb. nov. Basionym— *Polypodium macrosphaerum* Bak. Kew Bull. 55, 1895. Synonym—*Lepisorus macrosphaerus* (Bak.) Ching, Bull. Fan Mem. Inst. Biol. **4** : 73, 1933

This species reported by Ching from China and Khasi hills of Assam, has since been collected from Subansiri F. D. NEFA (cf *Panigrahi 19858*).

Pleopeltis macrosphaera (Bak.) Panigr. and Patn. var *asterolepis* (Bak.) Panigr. and Patn. comb. nov. Basionym—*Polypodium asterolepis* Bak. Journ. Bot. 230, 1888. Synonym—*Lepisorus macrosphaerus* (Bak.) Ching var. *asterolepis* (Bak.) Ching, Bull. Fan Mem. Inst. Biol. **4** : 74, 1933.

This species reported by Ching from China and Himalayas, has been collected by the Eastern Circle, B. S. I:, Shillong from Assam and NEFA on 5 different occasions.

Pleopeltis oosphaera (C. Chr.) Panigr. and Patn. comb. nov. Basionym—*Polypodium oosphaerum* C. Chr. Contr. U. S. Nat. Herb. **26** : 334. pl. 29, 1931. Synonym—*Lepisorus oosphaerus* (C. Chr) Ching, Bull. Fan Mem. Inst. Biol. **4** : 70, 1933.

This is undoubtedly a very rare species, reported by Christensen (l.c.) from Siam and by Fischer** (1938) from Lushai Hills of Assam. We have had no luck in examining any specimen belonging to this species either in the field or in the herbaria.

Crypsinus stracheyi (Ching) Panigr. and Patn. comb. nov. Basionym—*Phymotodes stracheyi* (Ching, Contr. Inst. Bot. Nat., Acad. Peiping **2** : 83, 1933. *Polypodium stewartii* Clarke, Tr. Linn. Soc. Il. Bot. **1** : 563, 1880. hom. illeg. (non *Pleopeltis stewartii* Bedd. Ferns br. Ind. t. 2, 1867).

Clarke (1880) described *Polypodium stewartii* Clke. from North West India. Ching (1933) considered this species as a species of *Phymatodes* and described it under a new name *Phymatodes stracheyi* Ching., since *Polypodium stewartii* Clke. (1880) is a later homonym under Art. 64 of International code of Botanical Nomenclature 1961, to *Pleopeltis stewartii* Bedd. (1867) which was an earlier validly published name. Later Copeland (1947) transferred this *P. stewartii* Bedd. to *Crypsinus stewartii* (Bedd.) Copel., which is also an Indian species, distinct from *C. stracheyi* (Ching) comb. nov.

The Indian distribution of this species is being claimed here on the basis of Clarke's (l.c.) report of the species from Sikkim and of Ching (l.c.) from Sikkim, Nepal and China. We had no occasion to collect this species in the wild state from anywhere in Eastern India. A specimen, *Stainton et el* 3642 from Nepal and deposited at Central National Herbarium, Sibpore, West Bengal has only been examined by us.

Acknowledgments

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**C. E. C. Fischer. The flora of Lushai Hills. *Records of Botanical Survey of India,* 12 (2) : 75-161, 1938.

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